MINE AND QUARRY

VOL. IV. NO. 1 JUNE, 1909

GARY, WEST VIRGINIA

VERMONT MARBLE, PART II

THE MAUCH CHUNK TUNNEL

MINING AT GARY, WEST VIRGINIA

PUBLISHED BY THE SULLIVAN MACHINERY CO. RAILWAY EXCHANGE BUILDING, CHICAGO.

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MINE AND QUARRY

Vol. IV, No. 1 JUNE, 1909.

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

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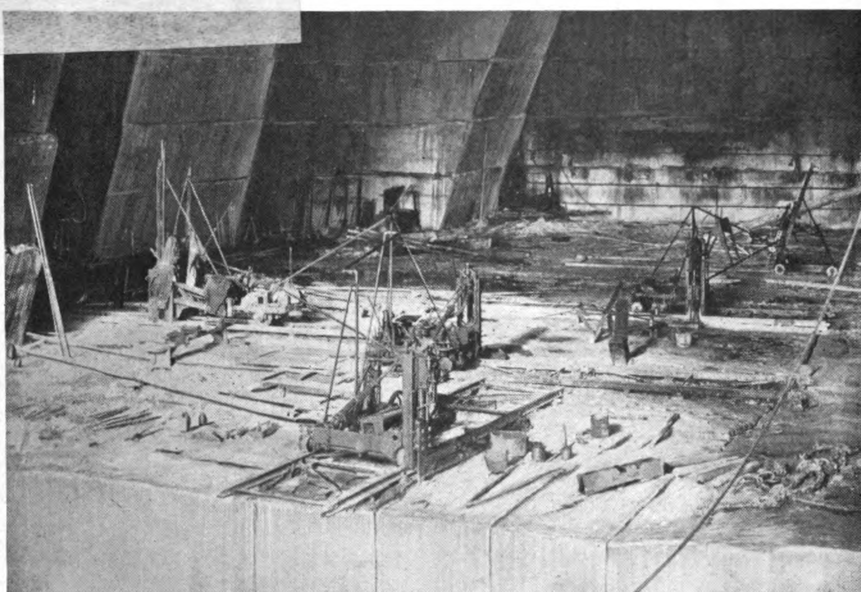
A "waste-basket" circulation is a depressing thing for any periodical to contemplate, particularly for one which has such a low subscription rate that Uncle Sam insists on eight cents a pound instead of one. Recipients of "Mine and Quarry" who find nothing in it of interest to them will confer a favor on the publishers by mailing the enclosed card, with a request to discontinue. On the other hand, acknowledgment of the magazine by those who *are* interested will insure the retention of their names on the list, in our periodical revisions.

The selection of methods and tools for given purposes, in order to achieve the highest degree of operating economy, demands incessant study and an ability to accept the results of others' experience. In certain mining districts two-man rock drills of one or another size have come to be regarded as "standard," for all work. Miners in these districts have been surprised to find how much more economical a light, or "one-man" drill is for many purposes, and the innovation, which has been "standard" in other fields for years, is rapidly making converts. In like manner, drills larger than "standard" have been introduced in camps where hard times had closed many operations, with the result that mines have thereby reduced their costs of ground breaking and are running on ore too lean to show a profit under the usual system. Here is a practical subject for mining institutes and congresses to study.

Eighteen years of coal mining, without a fatal accident from exploding gas or dust, is an excellent record for any mine. It is especially deserving of praise because the company achieving it is the largest coal producer in the world. Readers will find much that is unusual in the methods of preventing danger and accident, employed by the coal mining department of the United States Steel Corporation, as described in an article on the Gary, West Virginia Mines, in this issue. Separate underground roads for the use of men only; prohibition of solid shooting; insistence on proper care of workings; scientific ventilation, and bonuses to officials for clean accident sheets, are a few of the causes which impelled the state mine inspector to report to Governor Dawson that these were the best mines he ever entered in his life. Such rules and conditions constitute a form of liability insurance which would be a profitable investment for any industrial corporation. Aside from the protection to human life, the effect of such an attitude upon the minds of employes is an incitement to better work and a deterrent to labor troubles.

One of the West Rutland Covered Quarries.



A Covered Quarry, from the inside. Sullivan Steel Channelers in foreground, Diamond Channeler at left.

VERMONT MARBLE. PART II

QUARRIES OF THE VERMONT MARBLE COMPANY

WRITTEN FOR MINE AND QUARRY BY H. J. MARKOLF AND D. J. O'ROURKE

[Editorial Note:— Part I of this article appeared in the March, 1909, MINE AND QUARRY, and described the quarries of the Norcross-West Marble Co., at Dorset, Vermont. The methods employed there are typical of the quarries in which the marble lies approximately horizontal. In Part II, emphasis is laid on the operation of inclined beds, and the workings and methods of the Vermont Marble Co. have been selected for description as being typical of this phase of the industry. Acknowledgment is made to officers of that company for their assistance in preparing this article.]

The Vermont Marble Co. hardly needs an introduction to the readers of this magazine. It is known to most of them as the largest producer not only of marble, but of cut stone of any kind in the world. Its quarries and mills are situated in Rutland County, Vt., in the towns of West Rutland, Proctor, Danby and Pittsford, in the heart of the Green Mountain district. Marble was quarried in Rutland County as early as 1837, by Humphrey Bros. of Sutherland Falls, the village which was incorporated in the eighties as Proctor. William F. Barnes organized the first marble quarry in West Rutland about twelve years later than the Sutherland Falls opening.

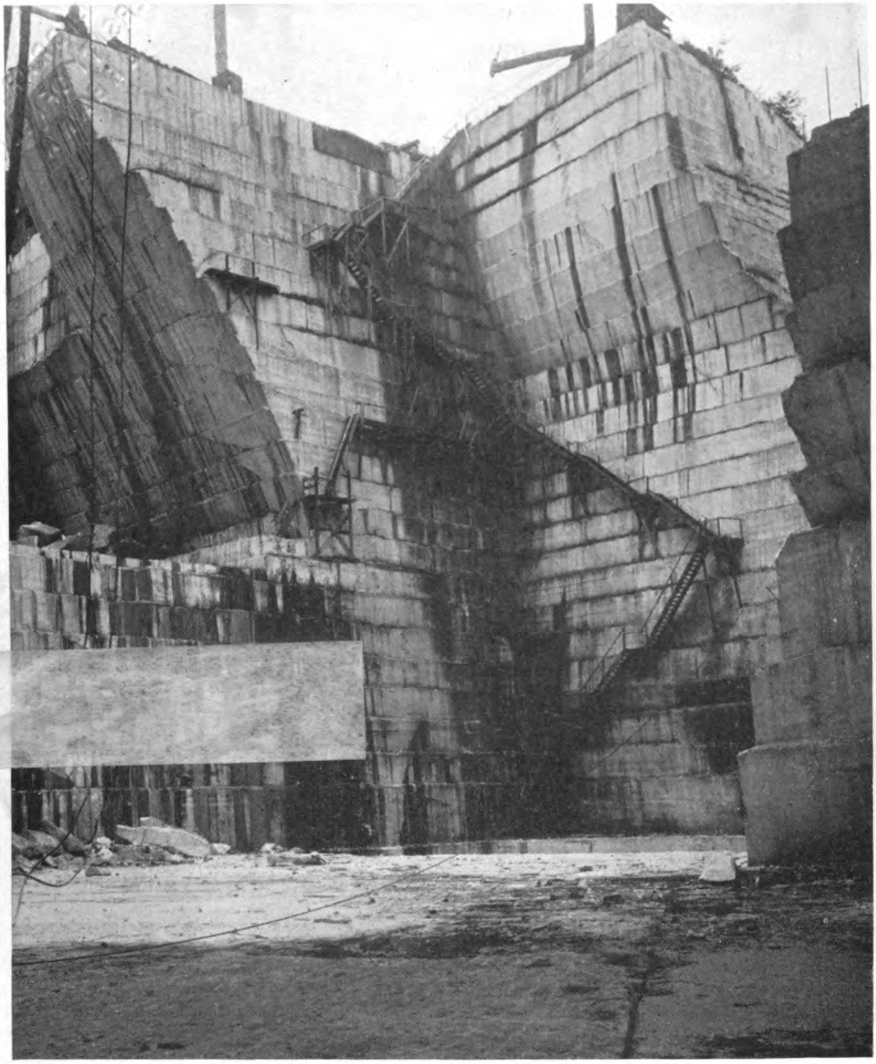
This was east of the present Sherman quarry. About 1853, the opening now called the Gilson & Woodfin quarry was established and was the first in West Rutland to produce statuary marble. In 1845, the pit since known as the Sutherland Falls Quarry was begun, see page 288. This is now 200 feet deep and is the largest open pit marble working in the world. These early enterprises were carried along on a small scale until the present company was organized by the late Senator Redfield Proctor in 1870. From that time forward, the industry progressed more rapidly. From an equipment of ten gangs and a force of 75 men, the Vermont Marble Co. has become the largest corporation doing business in the State of Vermont, with an enormous quantity of equipment and between 3,500 and 4,000 workmen at its different properties. The company has organized and owns the Clarendon and Pittsford Railroad, connecting the different quarries and comprising 20 miles of main line track. The annual pay roll amounts to over $1,500,000.

CHARACTER OF THE BEDS

The extensive quarrying of marble in this field presents physical difficulties which were not solved until about 1870. In this part of Vermont nearly all the marble beds are tipped at angles ranging from 15 to 45 degrees. The stone improves in quality with depth from the outcrop, but there is a vast thickness of worthless cap rock, overlying the veins. Stripping is out of the question, and the early quarry men had to be satisfied with such stone as they could secure by working vertically from the outcrop.

THE DIAMOND CHANNELER

In 1869, Mr. Albert Ball, then mechanical engineer for the Sullivan Machine Co., as he is now for its successor, the Sullivan Machinery Co., designed the diamond channeler, and the diamond gadder. The former consisted of a frame on wheels, running on a portable track, (See cut, page 289). At each end of the frame was a diamond bit, rotated by gearing and fed into the rock by a screw feed. This machine possessed the advantage of being able to cut at any angle desired, boring a large number of holes at close intervals to form a groove or channel. It then became possible to follow the sloping beds of valuable marble in under the hills, and to excavate much more rapidly



The deep Sutherland Falls Quarry.

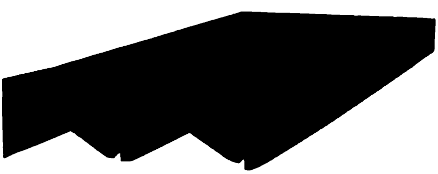
and cheaply than by hand. With this invention, production grew apace, and became more of a mining than a quarrying operation. The reproduced photographs on pages 286 and 291 show how small some of the openings are, and the other pictures in this article give a further idea of the magnitude of the workings developed by this process. Page 294 indicates the characteristic method of opening one of these quarries. Here a square shaft has been carried down to the beginning of the good stone, and tunnel cuts are being driven from this point in all four directions. The quarry floor, in the meantime, is cut up into blocks by cross channels.

The Vermont Marble Co. still owns 20 Sullivan diamond channelers, but their use has gradually diminished with the advancing price of diamonds, due to the widening application of the diamond core drill.

STEEL CHANNELERS

About 1888 or 1889 the Sullivan swivel head direct acting single gang steel channeler was perfected by Mr. Albert Ball, and since that time has remained with various improvements in details, the standard marble quarrying machine in Vermont and elsewhere. The Vermont Marble Co. now owns about 80 of this type, out of a total of 104 steel channelers.

The Sullivan marble channeler has a 6½-inch cylinder, and is able to cut at any angle from vertical to horizontal, in the usual direction, i. e. at right angles to the line of the track.

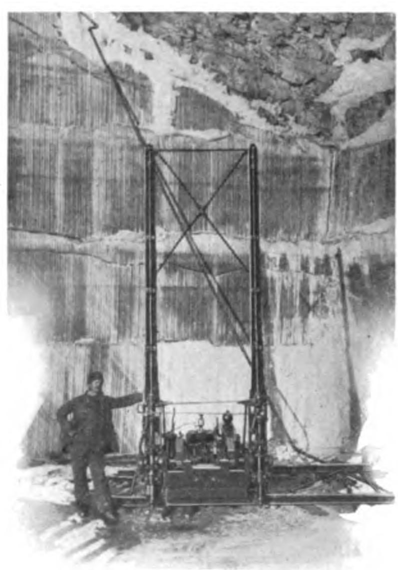


The diamond channelers were unable to swivel in the same plane as the cut, to channel into the sloping walls at the end of the floor, or to cut out corners. The steel channeler, however, may also be swiveled on its frame to cut into walls or corners, at any angle up to 27½ degrees, or to 75 degrees, by adding special braces. The machine is too well known to quarrymen to need further description here. A recent labor-saving improvement consists of a set of sprockets and a chain for running up the feed screw by power instead of by hand, when necessary to change steel. The accompanying cut shows the standard marble gang bit of five pieces.

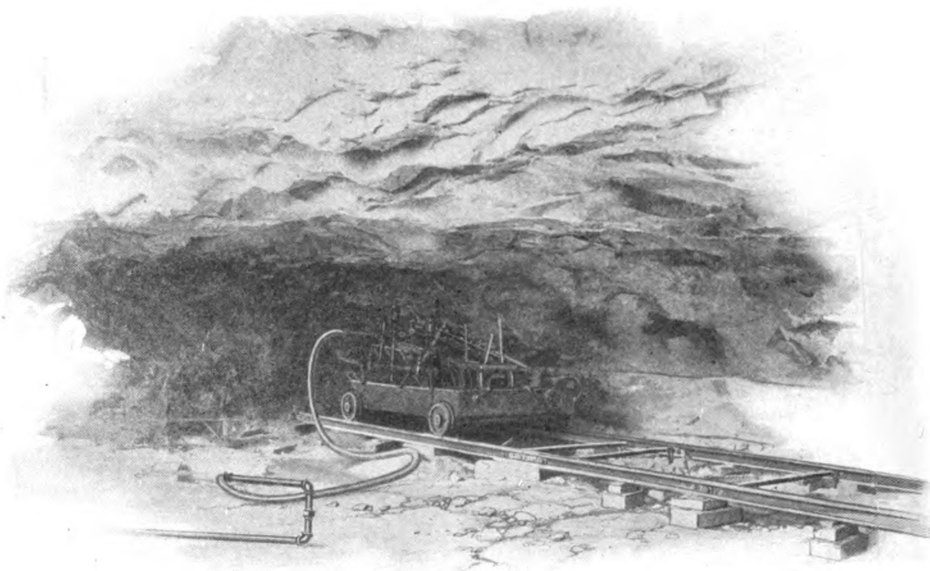
At Pittsford, Vt., one of these channelers has cut over 3,800 square feet in a 60 days' test run, and 5,400 feet in 90 consecutive days, at Pittsford and Proctor. Monthly records of individual machines at one of the West Rutland quarries, made several years ago, were 2,652 feet, 2,649, 2,287, and 2,449 feet, while the record of eight machines for one month showed an average of 1,846 feet.

QUARRY METHODS

The West Rutland quarries represent the typical methods employed in the district, and more detailed mention of them may be in place. There are seven or eight of these openings in the hillside, on an incline of 15 to 45 degrees, pitching east, and following the hill for about 3,000 feet. Several of these are connected by a tramway along the bottom floor, and blocks are handled by a motor car to an incline, upon which they are run to the quarry bank. The deepest of these quarries has reached a depth of 200 feet vertically, and from the open pit, angle



Sullivan Diamond Channeler.



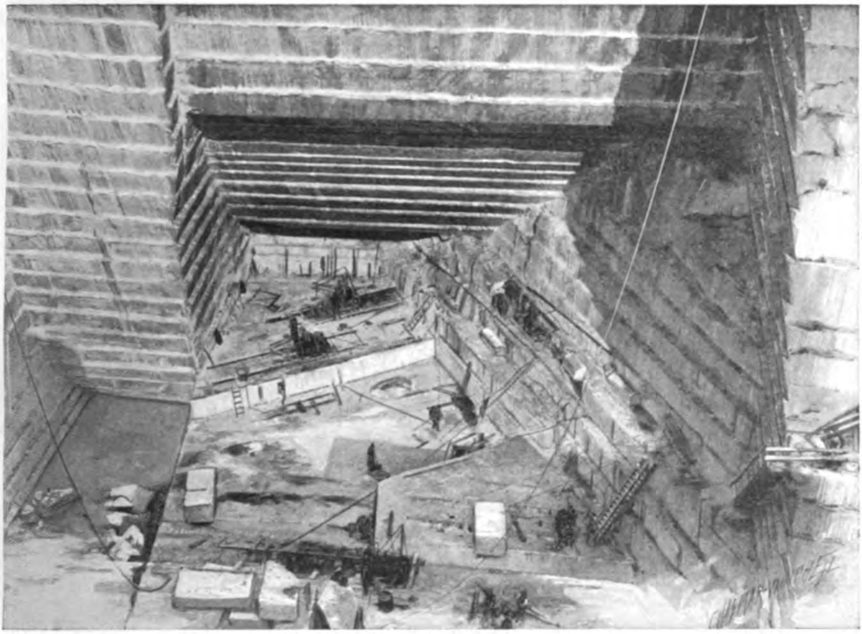
A Sullivan Improved "Class 6½" Channeler making a tunneling cut at West Rutland. The roof is about six feet high. (From a flash-light photograph.)

cutting or tunneling has been carried on to the east some 200 feet, and to the west nearly 300 feet. The workings have never reached the limit of the deposit of marble in either direction, as indicated by prospecting with a Sullivan Diamond Core Drill.

The cut above shows a Sullivan channeler making an angle or tunneling cut 9½ feet deep. This machine is between 200 and 300 feet from the open pit, and the picture was taken by flash-light. The roof here is about six feet high and the cut, when completed, will come down to the level of the quarry floor. The method employed in this quarry for increasing the producing area in the covered portion is shown by the rough sketches on page 292.

No. 1 corresponds to the photograph above. When the cut made by the channeler is completed, the track is moved along the floor and a new channel started. An unbroken line of channel, at times 100 feet in length, is put in, and as the channeler is moved along, the worthless marble or cap rock is blasted out so that the work of channeling is not interfered with. In the center of this sketch is shown a channel cut, indicating the method of extracting marble as the floor advances. At the left is a quarry bar with a drill, which shows the way in which this tool is set up for drilling the bottom holes. A special rock drill is used for this purpose, with the steam chest on the side, so that the drill can put in holes, which are practically at the floor line.

Figure No. 2 shows the method of drilling the holes to complete the removal of the face of worthless rock begun



Sullivan "6¼" Channelers at Proctor, Vermont.

by the channeler. The bottom hole is fired first, removing the stone between the floor and the channel cut. The second line of drill holes, above the cut, is then placed, and the rock removed before the roof holes are shot. When the new face is opened up the channelers are again put to work, and in the meantime, the quarry floor is advanced by the bench system, as shown in the sketches. After the longitudinal and cross vertical channels are made in the floor, and the bottom holes drilled with quarry bars, a vertical line of holes is drilled at proper intervals, as shown in sketch No. 2, either with a gadder or quarry bar, to split the blocks up into suitable sizes for handling. These blocks are split off from the main layer by means of "plug" and "feather" wedges. A chain is then placed around the block, and it is hauled out to the open pit by means of a stub derrick, so that the derricks on the bank can raise the blocks to the surface. The stub derrick is advanced from time to time so as not to have too long or too flat a haul for the blocks. The company has, at its various quarries, 65 Sullivan drills, bars and gadders, and 77 block derricks and traveling cranes. In drilling the gad holes for removing the blocks, as above described, throughout the district, the flat bit with diamond point, as shown in figure No. 3, has until the last few years been the standard method of sharpening the steel. Many of the quarry-men have more recently taken up the cross bit with diamond point, which is generally recommended by drill manufacturers for quarry purposes. The objection to the flat bit is the difficulty of securing proper rotation for round holes. In marble, only a minute or two is needed to put in a hole two or three feet deep, with one of these drills. The work done with each stroke of the drill is considerable and creates a tendency to form lumps in the hole, so that there is a large amount of wear on the

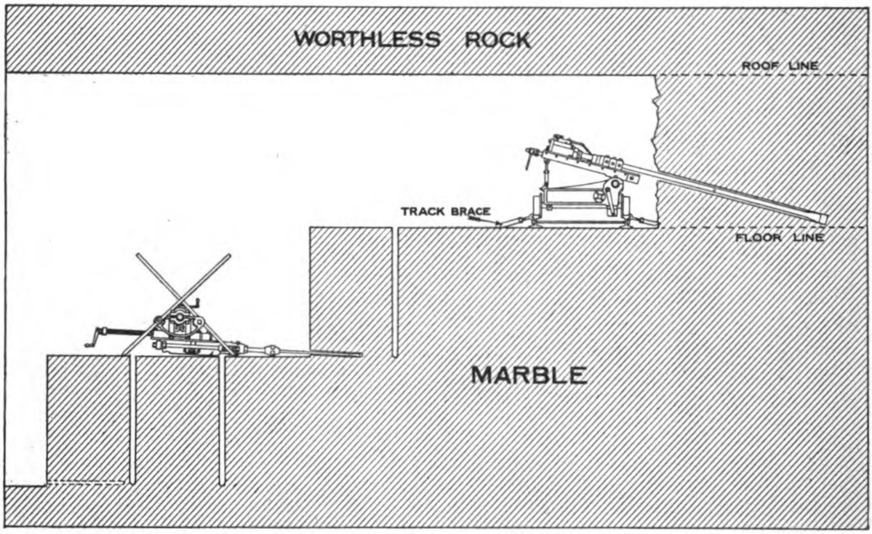


Fig. 1.

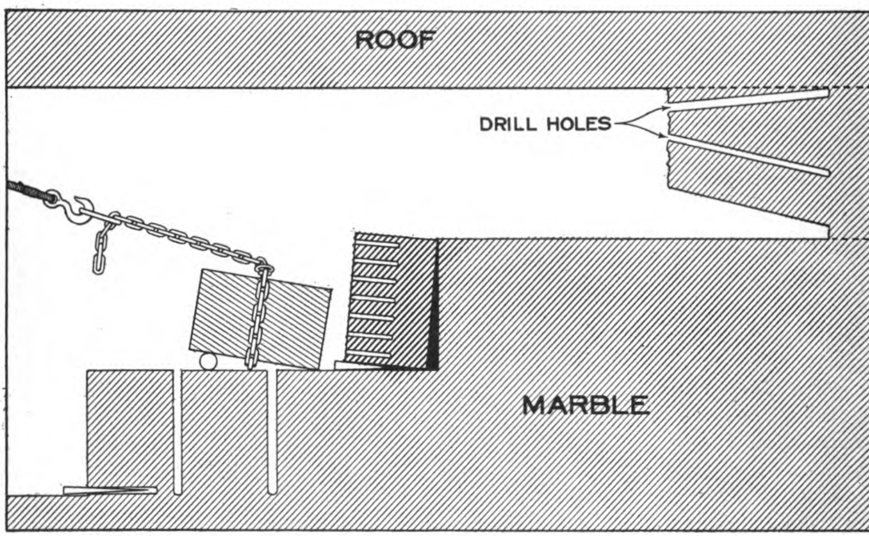


Fig. 2.

rotating device, and also frequent sticking of the bit in the hole, which causes delay and cylinder wear. These objectionable features are altogether eliminated by using the cross bit. The progress may not be quite as rapid in one or two given holes, but in a day's work or week's work, the amount of drilling done with the cross bit will equal, if not surpass, that accomplished with the flat bit, while the wear and tear on the drill is greatly reduced.

FINISHING

When the blocks come from the different quarries, usually 6 x 6 x 8 or 10 feet in size, they are placed in the storage yard until required, and there loaded to the company's railroad cars for delivery to its various mills by the large 60-ton traveling crane, which is one of the sights of the vicinity. This crane is shown on page 296. The company keeps from 15,000 to 17,000 quarry blocks in stock at all times.

The kinds of marble secured range from those suitable for exterior building work, to marble for interior building decorations, monuments and statuary. A very large business is also done in plumbers' slabs, etc. The quarries produce marble of the purest white, and veined marble in all tinges of gray and blue, which is beautifully matched for building work. Gray and blue marbles are also secured, which are largely used for monumental purposes.

The company has the largest marble finishing works in the world at West Rutland, Center Rutland and Proctor. Their equipment includes 20 acres of floor space, 368 gang saws, which are in operation day and night, 79 rubbing beds and over 300 pneumatic cutting and carving tools. Over 6,000,000 feet of lumber are used every year for boxing and other purposes.

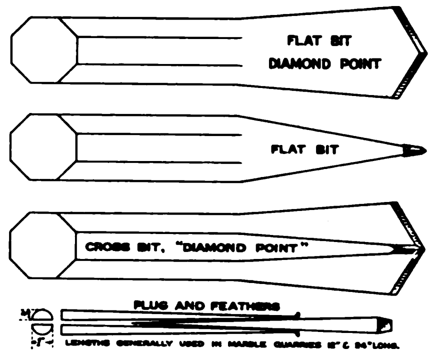
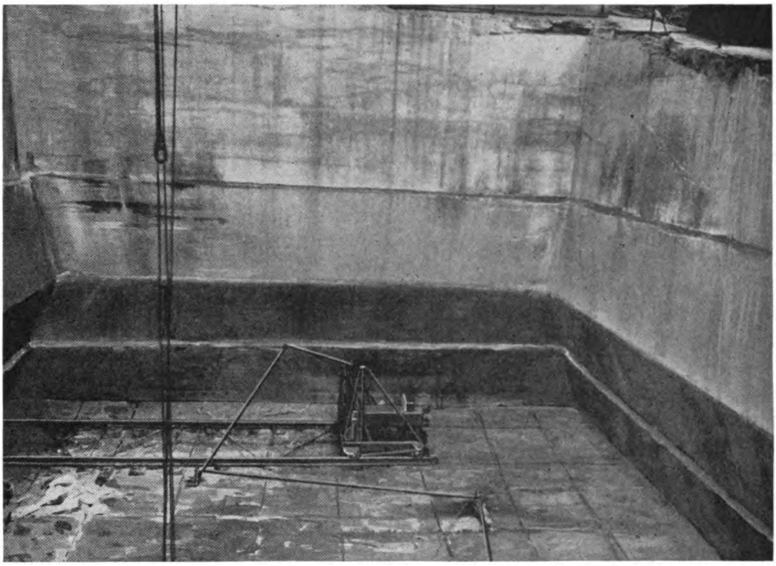


Fig. 3.

Power for the quarries is obtained from Sutherland Falls, on Otter Creek, at Proctor. This beautiful fall, 124 feet high, produces 3,900 horsepower, of which 2,400 is transmitted by electricity to West Rutland. There is also a 1,000 horsepower Corliss engine at West Rutland to generate electricity during the dry season. At Beldens, Vermont, about 4,000 horsepower is available for development from running water. At Center Rutland, there are also a finishing shop and three marble mills, run by water power. The company

Rock Drill on Quarry Bar, showing position for bottom holes.

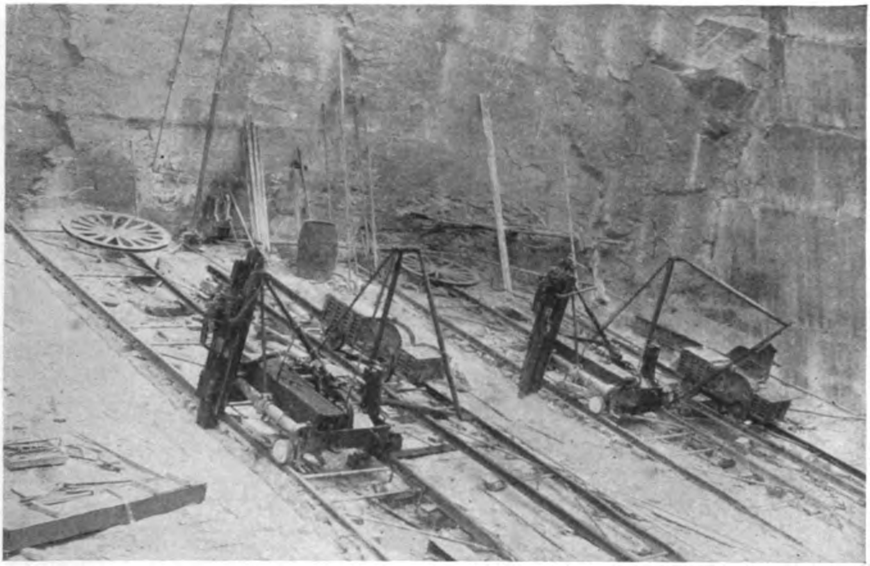


A new opening, showing the beginning of angle cutting.

maintains its own machine shops at Proctor and West Rutland for making repairs to its equipment. Power for the channeling machines and drills is furnished by steam boilers at the different quarries. An interesting feature of the marble mills is the method of securing sand for the gang saws. This sand is brought over the hills from Pittsford by an aerial tramway, two miles in length, on electric power furnished from Proctor. It is carried in buckets, which average one to every thirty feet of cable.

A visit to the quarries is one of the great interest for even the layman. The location of the industry is one of physical beauty which it would be difficult to equal anywhere in this country. The deep valleys and abrupt hills of the Green Mountains, heavily wooded, furnish a wonderful background for the white marble pits and acres upon acres of blocks and slabs. The country roads in this part of the state are paved with crushed marble, the sidewalks are made of marble slabs, and to one unaccustomed to seeing this valuable stone, except in monuments or buildings, there seems to be a lavish use of it, which is almost wasteful. In visiting the quarry pits, the traveler who is sufficiently inquisitive, is led down a steep ladder, some 100 or 200 feet, to the bottom of the quarry, or to a hole in the side of the hill, into which it is difficult to see more than a few feet, on account of the steam. In this atmosphere, the electric arc lights are merely an aggravation of the gloom. One is told that in this quarry there are "about 12 channelers," but he could not believe it, except for the deafening roar which he knows must come from the blows of the steel and the exhaust. Nothing short of a photographic flash-light will reveal these busy machines and their operators, until the visitor is almost near enough to feel them as well as see them.

One could spend days in visiting the various mills and finishing shops, following the stone as it comes from the slow and ponderous gang saws to the polishing beds or planers, or is carved and molded



Sullivan Side-hill Channelers with balance cars on a steep slope at Proctor.

under skilled hands into delicate forms. Machinery does many wonderful things in these plants, one of those amusing to the novice being the turning of an oval hole in a washstand slab without hand labor.

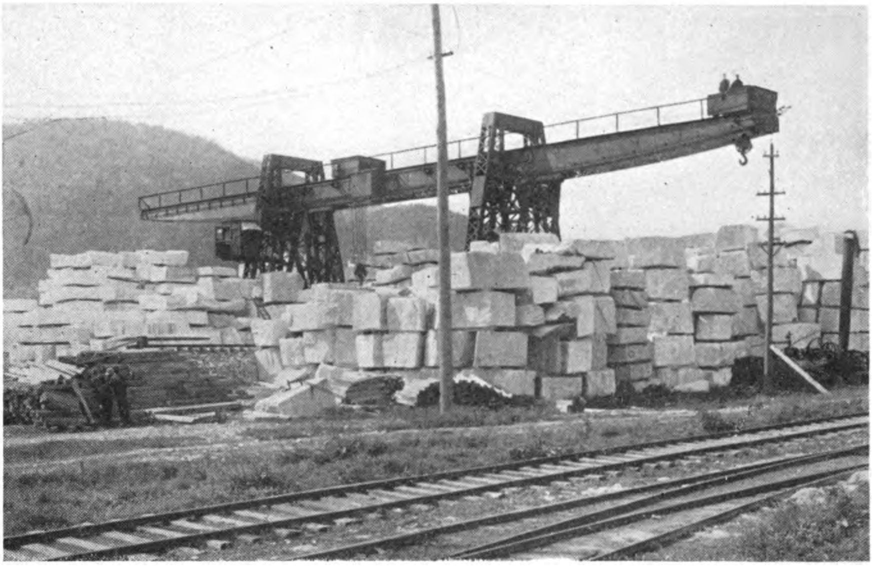
LABOR CONDITIONS

The ability and keen insight of the late Senator Redfield Proctor and his son, Fletcher D. Proctor, who has recently finished a term as governor of his state, have made this industry what it is to-day. From an economic view, one of their most interesting and valuable achievements is their solution of the labor problem. Many of their employes are of foreign nationalities, but labor troubles are few and far between.

For a number of years the company has maintained company stores at Proctor, West Rutland and Center Rutland, and since about 1903 all profits made have been divided among its employes. Each employe who buys goods at the store receives at the end of the year a cash dividend based on the profits of the business and the amount of his purchases. Non-employes receive no dividends from their purchases. In one year the sales at Proctor alone amounted to $230,000, and the net profit to $20,000, after deducting all expenses, including four per cent. interest on the money invested in the business by the company. The Proctor employes received rebates of eleven per cent. on their purchases, those at West Rutland, ten per cent., and those at Center Rutland eight per cent. The sales to buyers other than employes at the three stores, amounted in that year to $115,000.

The company has built a handsome marble club house for its employes at West Rutland, a Y. M. C. A. building, a library and a hospital at Proctor. Much of the hospital service is rendered gratis, while the rates charged are so low that the actual income from paying patients amounts to only a small percentage of the running expenses. A free visiting nurse organization is also maintained.

A list of the structures, monuments and



The 60-ton Crane at West Rutland.

General View of Proctor; Finishing Works in Center.

decorative work in which the Vermont Marble Company's products are in use would require a separate catalogue. Prominent among recent buildings in which its marbles have figured, however, are the Senate Office building, the National Soldiers' Home and the Department of Agriculture, at Washington, and the Knickerbocker Trust Company building in New York City.

NOTES ON MINING AT COBALT

WRITTEN FOR "MINE AND QUARRY" BY R. T. WALKER*

The rich silver camp of Cobalt in Northern Ontario, which has attracted so much attention during the past five years, has thus far produced a total of 37,483,308 ounces of silver, or a total value of $21, 496,197.

The veins of native silver first noticed by the prospector were on the surface, covered with but a few inches to a few feet of moss and dirt. The impulse to take out the rich ore in sight by means of open cuts was at first followed by some of the mines, but after a short time this plan was abandoned, and scientific mining methods have since been employed. Modern plants were installed as rapidly as possible, and there are at the present time 36 producing mines within an area of less than six square miles, not to mention prospects, where indications and formations give promise of more "shippers" in the near future. Seventeen of these 36 have been and are paying handsome dividends to their shareholders.

In the year 1908, 87 per cent. of the silver output of Canada and 9 per cent. of the world's output came from the Cobalt camp. The estimated production for Canada was 22,070, 212 ounces, as compared with 12,779,799 ounces in 1907, an increase of over seventy-two per cent. During that year Cobalt was the heaviest silver-producing camp in the world.

While the production increased 72 per cent., the total values showed a gain of only 40 per cent. due to the drop in the price of silver. In 1907 the average price of silver was $.6532 per ounce. The shipments from the Cobalt camp totaled 25,497 tons, which yielded 19,296,430 ounces of silver, valued at $10,200,865. From these figures it will be seen that every decrease of one cent in the price of silver means a loss of approximately $200,000 to the camp.

GEOLOGY

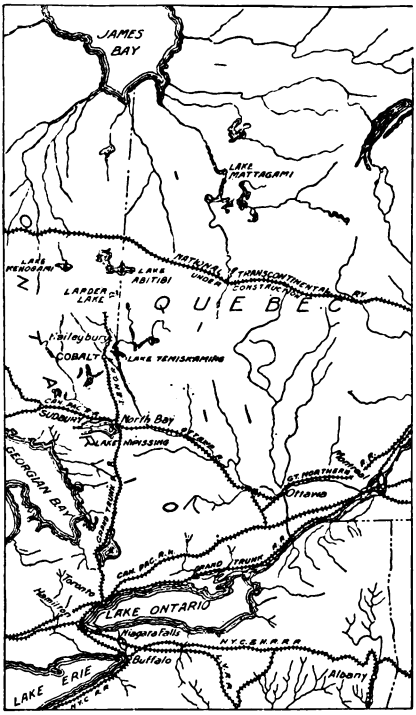
In the Cobalt district there are three distinct formations of economic importance, and in which mining operations are carried on. These are, first, the Keewatin, an igneous complex, which is the oldest rock in this area and underlies the whole district; second, the lower Huronian conglomerate and slates, which are made up of particles of the Keewatin and Laurentian granites and which overlie, in some portions of the area, the Keewatin; and third, the diabase, an eruptive rock which intruded into the older measures and which undoubtedly at one time covered a large part of the area. Glacial action has eroded this latter formation to a considerable degree and the older rocks are exposed in some places. The diabase is conceded to be the formation responsible for the silver enrichment.

The ore bodies occur in fissure veins, which are narrow and irregular in strike, caused by the cooling of the diabase. These veins are filled with calcite, cobalt, nickel, arsenic and silver, deposited by impure waters and vapors which followed the diabase intrusion.

PROSPECTING

Prospecting is carried on to a large extent by means of surface trenching. By this method many important veins have been located, although by no means all of the veins show values at the surface, and in many cases what appeared to be barren

*Cobalt, Ont.



Map Showing Position of Cobalt and New Districts in Ontario.

Courtesy Mining and Scientific Press

leads have, upon exploitation at depth, proved to carry silver.

On account of these numerous barren leads, which are usually nearly vertical, diamond drilling, both from the surface and underground, is also extensively employed and has done much for the development of the district. Another valuable service performed by diamond drilling is to test the formation without regard to values, as surface indications are often misleading and the development of the camp has shown that diabase, in many parts of the area overlies the lower Huronian formation, in which fully 90 per cent. of the important producing veins have been found.

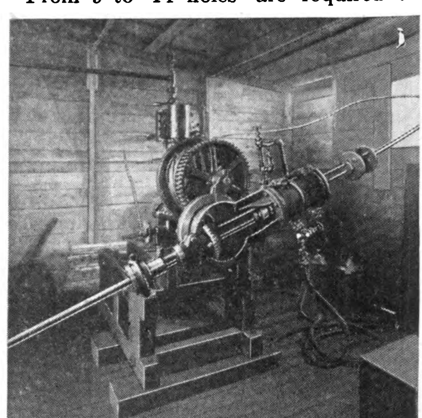
The drill holes are usually put in at angles ranging from 10 to 45 degrees, to depths of 150 to 400 feet, to test the persistence of the surface showings. The rate of advance varies from 5 to 8 feet per shift. The Sullivan H, Beauty, and S diamond drills are the styles most frequently used for this work, the first removing a 1⅛ inch, and the last two a 15/16 inch core. These machines are compact and readily moved from place to place. Roads are few, and the country is rough, swampy, and, before clearing, covered with thick timber and bush. This page shows a Class C drill outfit set up on the property of the O'Brien Mining Co., for drilling an angle hole from the surface. An S diamond drill underground is illustrated on page 299. The overburden encountered in surface prospecting is light so that but little drive piping or casing are needed. There are now about 17 diamond drill outfits at work in Cobalt and vicinity.

MINING METHODS

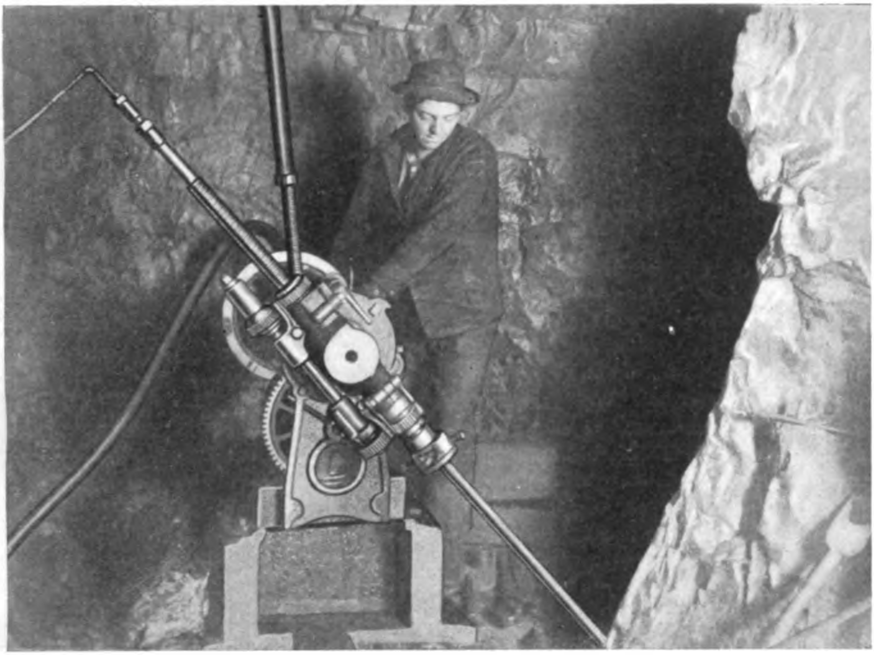
Mining is carried on in the usual manner, drifts usually five feet wide by seven feet high being driven on the veins at the different levels.

The rock is exceedingly hard but breaks well, and 3¼ inch air drills are commonly used. An average of 30 to 40 feet of holes per shift is considered satisfactory drilling.

From 9 to 14 holes are required to



Sullivan "C" Diamond Drill on an angle hole at the O'Brien Mine.



Sullivan "S" Diamond Drill at work underground.

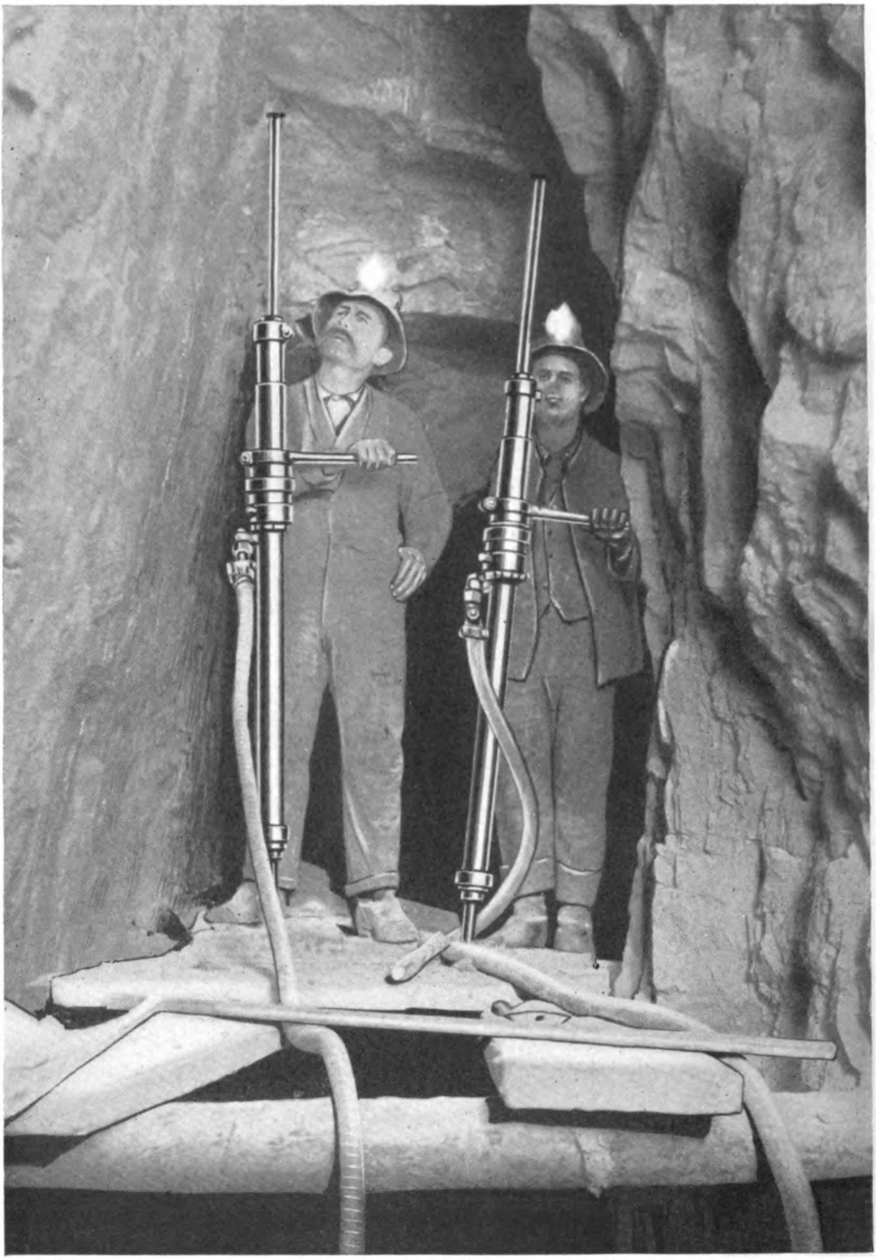
make a five-foot break in a five by seven-foot heading. No timbering is required, for by scaling off the loose rock from the walls and roof as the drifts and cross-cuts advance, later falls of rock are almost entirely avoided.

Overhead stoping is very widely employed for extracting the ore. Stulls and timbers are set in the drifts, with chutes every 15 feet, from which the ore and muck are drawn only fast enough to give space for men to work in stopes on top of the muck.

In some cases, in addition to values in the vein itself, native silver is shot into the wall rock and appears in leaves and slabs of various sizes. In such instances the stopes are carried wide enough to extract all the mineral-bearing rock. Usually, however, the values are confined to the vein, and the stopes are carried as narrow as possible, that the handling of barren waste rock may be reduced to the minimum. Here the Sullivan air feed D-21 hammer drills are found to be admirably adapted to the work in hand, and with them, stoping can be conducted at a cost of 35 to 50 per cent. of that sustained when reciprocating drills are used; these necessitating wider places in which to be set up and operated. The cut on page 300 shows a stope and the drills referred to.

POWER EQUIPMENT

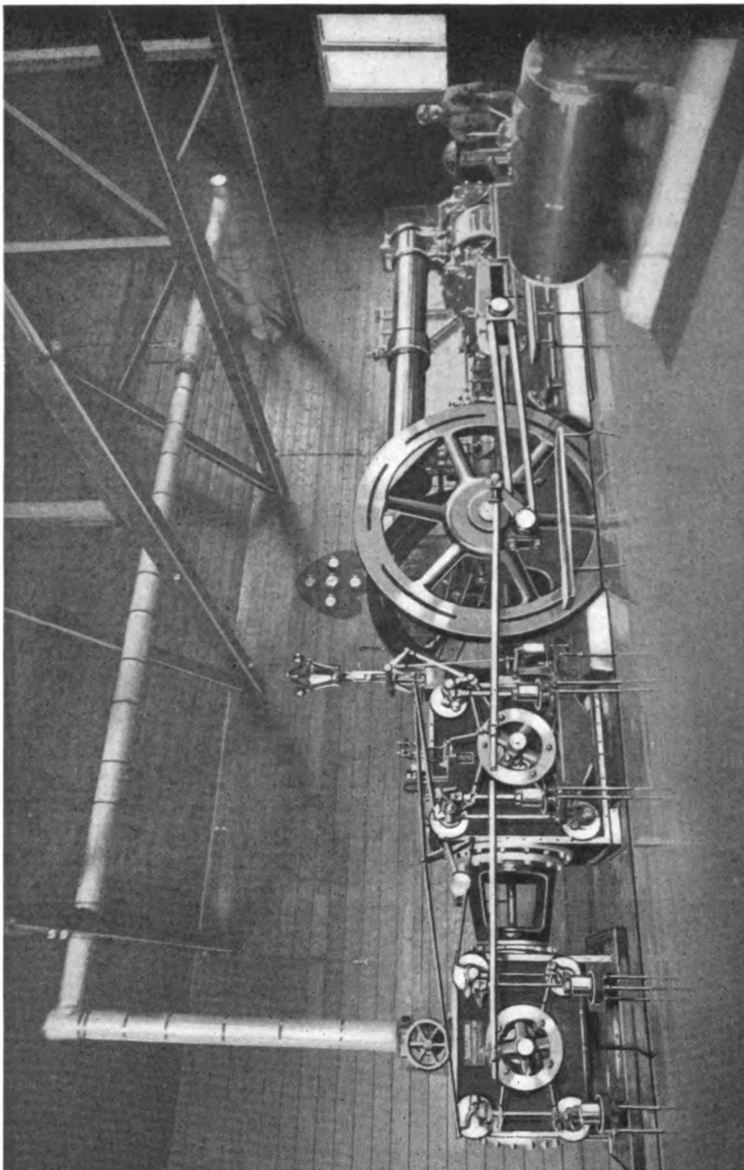
Coal for hoisting engines and air compressors is brought from the United States at a cost of $6.00 to $7.00 per ton, depending on the length of haul and the condition of the roads. For this reason much attention has been given in the camp to the economical production of power. The first air compressors installed were inexpensive, single stage machines, of low first cost, but relatively high steam consumption. More recently a number of two-stage air and compound steam compressors have been placed in service. A type which is receiving some favor, is the Sullivan



Stoping with Sullivan D-21 Hammer Drills in the La Rose Mine.

Class "WC," a compressor with tandem compound Corliss steam cylinders and two-stage air cylinders, as shown in the illustration of the machine, on page 302, owned by the Temiskaming Mining Co. The Corliss valve gear on both steam cylinders secures first-class operating economy, while the design of the machine, following that of the straight line type, permits a cost of manufacture, transportation, and installation very much lower than is possible in the case of Corliss cross compound compressors. The Temiskaming machine has a rated capacity of 1843 cubic feet of free air per minute, at 100 R. P. M. Other air compressors of this type in the camp are owned by the Crown Reserve Mining Co., Ltd., a photograph of whose surface workings is shown below; the Kerr Lake Majestic Mines Co., Ltd., and the City of Cobalt Mining Co., Ltd. There are also a number of the Sullivan standard, two-stage straight line compressors, Class "WB-2," in the camp. The Cobalt Hydraulic Power Co., a local enterprise, is constructing a Taylor Hydraulic Air Compressing plant on the Montreal River, at Ragged Chutes, where a fall gives a good head of water. It is the plan of this firm to supply air power to the entire district at very low rates, since the only expenses involved are those of construction and of pipe lines. The rock shaft and compression chamber which form the principal elements in this system, are being constructed with the aid of a Sullivan belt-driven air compressor, Class "WJ," and Sullivan 3¼ inch drills. Compressed air will be ready for delivery on August 1, according to the *Mining and Scientific Press*, which says:—"To bring the air to Cobalt nine miles of 20-in. pipe will be laid. The loop-line will start from the end of the La Rose bridge and will encircle the town, joining with the main line afterward. In the loop and the various branches around Cobalt the pipe will be 12 in. In addition to the loop there will be branch lines by way of the Colonial and the Nova Scotia. Another line will run to Kerr Lake. A pressure of 110 lb. per square inch will be maintained and the following rates per

Plant and Office Building, Crown Reserve Mining Co., Limited.



Sullivan Class "WC" Air Compressor of the Temiskaming Mining Co., Cobalt, Ont.

drill per 10-hour shift have been fixed for smaller customers: One drill, $5; two drills, $4; three drills, $3.50; four drills, $3.13; five drills, $2.80.

ORE DRESSING

Practice has shown it profitable to mill ore running from 15 ounces to 100 ounces of silver to the ton. Where it runs over 100 ounces it is more profitable to ship direct to smelters, which secure an average recovery of 85 per cent. This has led to the erection of seven mills, which are at the present time in operation in the Cobalt camp. Five of these are private and two are custom mills. Two more are now building and several others are under consideration.

Where mills are on the property, only the ore which is readily recognized underground as high grade is sacked on the spot, the balance being milled. In this case it is run through the regular succession of crushers, rolls, ball mills, jigs, stamps, tables, and cyaniding.

The principal points to which the ore is shipped for treatment are: Perth Amboy, New Jersey; Denver, Colorado; Copper Cliff, Ontario; and Deloro, Ontario.

The phenomenal success of the Cobalt camp has attracted so much attention that extensive prospecting has been carried on in the adjoining regions of Northern Ontario. Silver bearing rock has been discovered in a more or less continuous belt, approximately 125 miles long and several miles wide, running from South Lorrain to Gow Ganda.

Much of this country is still inaccessible to any but foot travelers except in winter, when traffic may be maintained on the frozen lakes and rivers.

DRIFTING RECORDS

The Vekol Mining Company, near Casa Grande, Pinal Co., Arizona, is advancing a drift in hard blue limestone from the 120 foot level. The size of the drift is 8x6x4½ feet, and the working face is now about 500 feet from the shaft. The drilling is done with a Sullivan "UC" 2¾ inch air drill on a double screw mining column. Two drill runners recently had a contest to see which one could break the most rock in five shifts, with the results shown in the following table:

The time for setting up included the time required by the men in walking from the shaft station on the 120 foot level until the air was turned on at the drill. The total working time included setting up, drilling, tearing down, loading and blasting. Seventy-five pounds of 1¼ inch powder were used per round of holes. A Sullivan Class "WB-2" straight line, two-stage compressor, furnished power for the drills at 110 pounds receiver pressure. The above information is furnished by Mr. W. J. Forbach, manager of the Vekol Mining Company.

Shifts	Set up Min.	No. of Holes	No. of Feet Drilled	Average Depth of Holes Feet	Total Working Time Hrs. Min.	Feet of Advance Ft.	In.
1	26	11	94	8.54	7:54	7	
2	16	11	95	8.6	6:25	6	11
3	19	12	102	8.5	7:15	6	9
4	21	10	85	8.5	7:10	5	1
5	17	12	92	7.66	7:02	5	½
Totals	99	56	468		35:46	30	9½
Averages	19.8	11.2	93.6	8.36	7:09	6	2

The Mouth of the Tunnel.

DRIVING THE MAUCH CHUNK TUNNEL

WRITTEN FOR MINE AND QUARRY BY L. R. CHADWICK*

What is probably the most extensive natural drainage system ever contemplated in the anthracite coal region has been undertaken by the Lehigh Coal & Navigation Company, for the purpose of draining the workings in the Panther Creek Basin. This basin lies between Locust Mountain on the north, and Sharp Mountain on the south, and extends from a little west of Mauch Chunk, Pennsylvania, on the east to Tamaqua, Pennsylvania, on the west. It is about 12 miles long by 2 miles wide at its widest part, and takes its name from Panther Creek, a small stream flowing toward the west and joining the Little Schuylkill river at Tamaqua.

The western end of the Panther Creek Valley workings have been drained through a water level tunnel into the Little Schuylkill river, but many of the workings are already much below this drainage level, and with increased depth the cost of pumping would steadily increase. At the eastern end of this basin, the Lehigh river is some 300 feet nearer tide level than the Little Schuylkill at the western end, so a system of connecting tunnels and gangways has been decided upon which will carry water from the workings to the Lehigh river, thus bringing the drainage level considerably lower. By this means a large territory of coal yet to be worked can be drained naturally, and the cost of pumping water from the lower workings will be materially lessened.

The outlet of this system will be through the Mauch Chunk Drainage Tunnel. This tunnel starts from the Lehigh river just above Mauch Chunk, and will be driven through rock for a distance of about 7,500 feet. At this point it will meet a drainage gangway in the coal which with other connecting gangways and tunnels, will give a continuous drainage way throughout the region, the total length of which is estimated at nearly fourteen miles.

When the Mauch Chunk tunnel was started considerable difficulty was experienced, as for the first 300 feet the ground was soft and timbering necessary. The Portland Contracting Company of Pottsville, Pennsylvania, took hold of the work when the tunnel had progressed about 1,500 feet, and have carried it along

*42 Broadway, N. Y.

in a very satisfactory manner. The contracted rate of advance was 225 feet per month, and in most cases they have exceeded this. They achieved the record for a month's work in tunnel driving in the anthracite region, when in October 1908 they advanced 311 feet.

The rock encountered is principally red shale and the hard conglomerate which underlies the coal beds, although some slate and sandstone has been met. The tunnel is advancing with the measures and at times is in both the shale and conglomerate. The size of the tunnel is 8 feet by 12, and the method of driving is shown in the accompanying cuts.

Figure 1 illustrates the manner of drilling the face in the hard conglomerate. Holes numbered 1 to 7 are the cut holes, 8 to 11 the relievers, 12 to 15 the side holes, and 16 to 21 the top and bottom holes. The cut holes are drilled to a depth of 8 feet and the others to a depth of seven feet. In blasting, the cut holes are fired first, the relievers next, then the side holes, and last the top and bottom together. Five and one half to six feet of rock are pulled at one time.

Figure 2 shows the system used in the red shale which is softer and more easily pulled than the conglomerate. Holes 1 to 4 are the cut holes; 5 to 8 the relievers, 9 a breaking down hole which is used only occasionally when the rock is a little harder than usual, 10 and 11 the side holes, and 12 to 15 the top and bottom. The cut holes are drilled 8 feet deep and the the others seven as in the conglomerate. The cut is fired first, the relievers and the breaking down hole (when it is used) next, then the side holes, and last the top and bottom. Six to seven feet are pulled in this rock.

The men work in two shifts, a shift consisting of a chargeman, who directs the three drill runners and three helpers, three muckers under a muck boss, a fireman and his helper, two dumpmen, a blacksmith and his helper, a "nipper" to keep the drills supplied with sharp steel, a motorman who runs the electric locomotive, and a mule driver. A foreman has charge of the entire job, and two men who work one shift keep the brattice(for ventilation) advancing as the tunnel advances, and repair and lay track.

The firing of the blast completes the work of one shift and the next shift comes on. The drillmen work with the muckers to clear a sufficient place for the columns to be set up. Then drilling begins as described above. The muck is drawn out to the dump by the electric locomotive, three carloads at a time, and dumped by the dumpmen. A mule pulls the cars out for the first two or three hundred feet to the point where the electric trolley line begins. Switches are provided at intervals in the tunnel to permit loaded cars going out to pass empty ones coming in. When the muck is all removed the muckers are through for that shift, and soon after, drilling the face is completed, and the drillmen and their helpers are through. Then

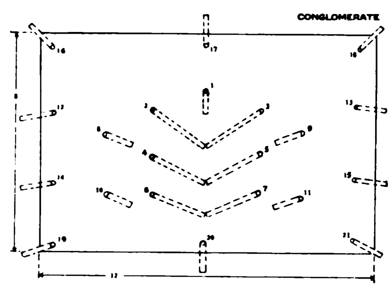


Fig. 1.

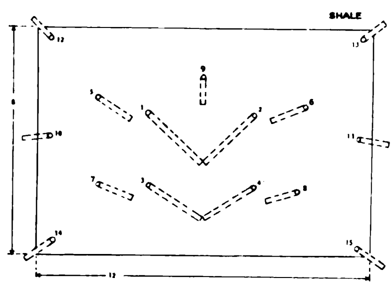
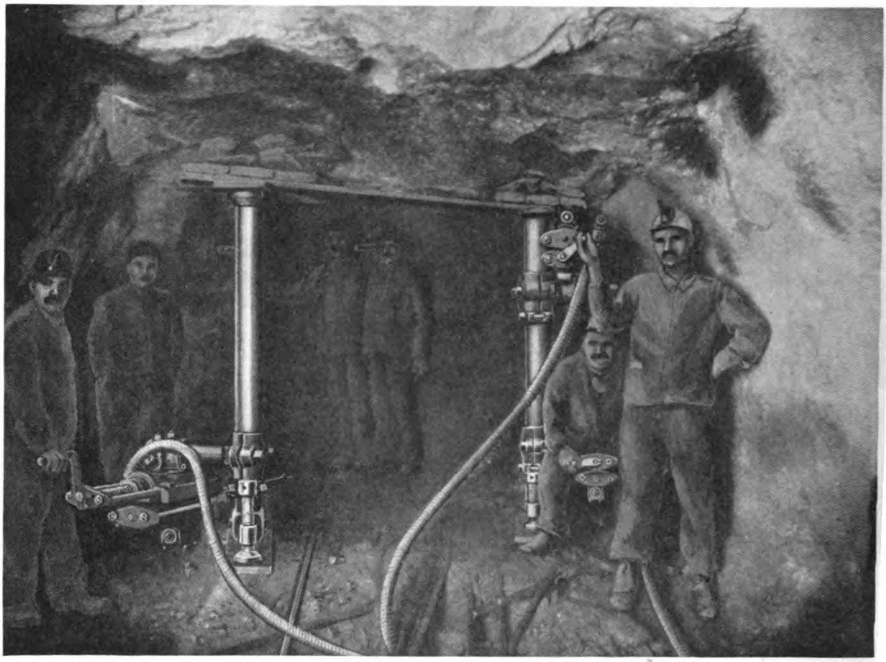


Fig. 2.



The tunnel breast, showing drills and mountings.

steel plates are placed on the floor of the tunnel to catch the broken rock as it falls, and make shovelling easier. Then the fireman and his helper load and fire the holes, and the work is ready to be taken up by the other shift. These operations take about 12 hours.

The men live together in a house near the tunnel, and one shift is always ready to go to work when the other shift is through, no matter what the time of day. In this way no time is wasted and the work is progressing during the whole of the 24 hours.

The tunnel is at present in about 6,800 feet. It is being driven with Sullivan "UH" 3⅝ inch differential valve drills, on two double-screw, mining columns. Drills of this make and type have been used exclusively by the contractors during the two years of their work at this point, and in low repair cost and high efficiency, they have proved themselves altogether equal to the demands upon them, and entirely satisfactory in every way.

We acknowledge with thanks the assistance of various members of the Portland Contracting Company in the preparation of this article.

Central Power Plant, at Gary, W. Va.

Town of Gary and Ovens at No. 1 Mine.

COAL MINING AT GARY, WEST VIRGINIA

WRITTEN FOR "MINE AND QUARRY," BY JOHN S. WALKER, JR.*

The United States Steel Corporation, in its search for high grade coking coal, to meet the constantly increasing demands of its numerous plants, some years ago leased fifty thousand acres in McDowell County, at the southern extremity of West Virginia. These holdings are on the Norfolk and Western Railway, about ten miles from Welch, and are in the choicest part of the Pocahontas field, along Tug River and Pinnacle Creek.

In 1902, prospecting and development were begun under the name of the United States Coal and Coke Co. The property was very thoroughly tested with diamond core drills, to prove the thickness and continuity of the seam, and to determine the best locations and methods for openings. The town of Gary was established as headquarters and shipping point, and under the direction of Colonel Edward O'Toole, general superintendent, and Mr. H. N. Eavenson, chief engineer, a thriving community has been installed in this mountain wilderness.

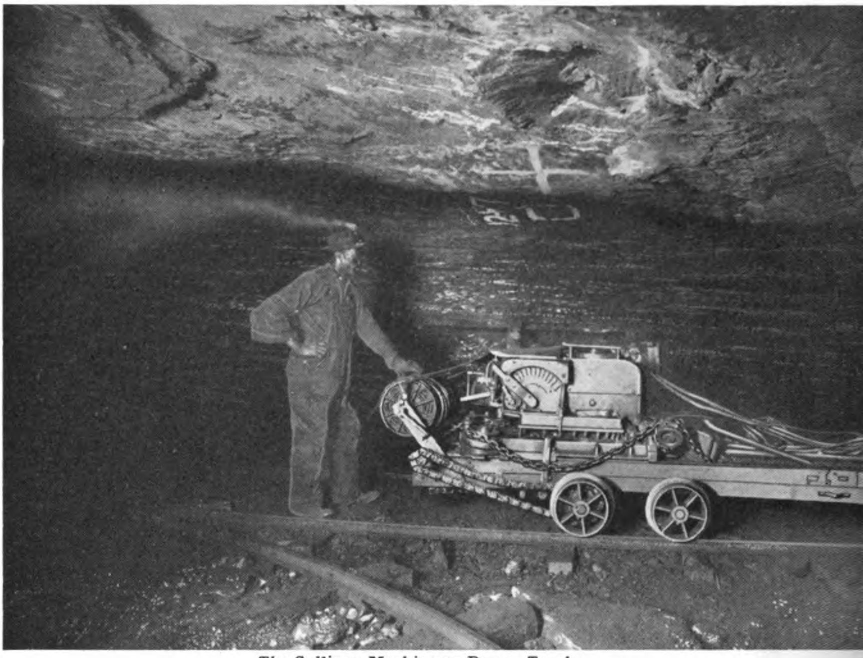
There are now twelve mines in operation, all fully equipped with the most modern and efficient machinery. During April of this year the production averaged about 9,000 tons per day. If this coal were all mined from one spot or working face, it would cover one acre in area per day.

At eight mines the company has erected large blocks of bee-hive coke ovens, numbering 2,151. About half the coal is made into coke at Gary, the remainder being shipped raw and coked at its destination. Most of the product is sent to the Illinois Steel Company's works at Joliet, and South Chicago, Ill., while a portion goes also to Sharon, Pa.

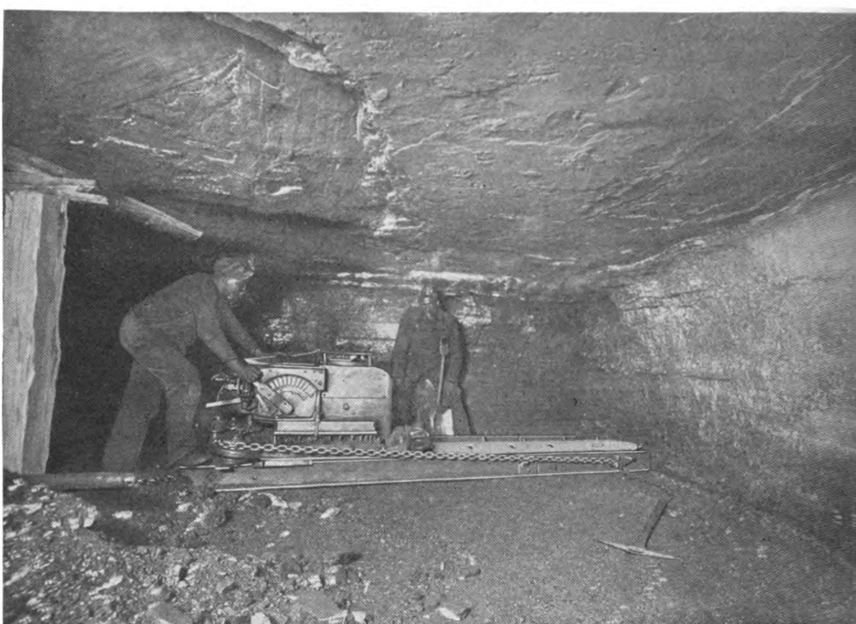
SYSTEM OF MINING

The company mines the No. 3 and No. 4 Pocahontas seams, which range from 4½

*Huntington, W. Va.



The Sullivan Machine on Power Truck.



Sullivan Electric Machine making rib or sumping cut.

to 8 feet in thickness. The coal is medium hard, and nearly level, and is overlain by slate, providing fairly strong roof. The mines are all worked from the outcrop, on the drift principle, except Mine No. 1, which is reached by a shaft 180 feet deep. The method of operation is practically the same in all the mines, with slight variations to suit local conditions. The rooms are turned on 60-foot centers, giving a 40-foot pillar and a 20-foot room. The entries, room necks and break-throughs are 12 feet wide. Props are set in the rooms from eight to ten feet from the face.

The entries are driven ordinarily on the quadruple system, although sometimes five parallel headings are driven to secure the best possible ventilation. All permanent overcasts and stoppings are built substantially of concrete and very heavy barrier pillars are left to limit the area affected in case of accident.

The haulage roads are built with plenty of room on the right side for cars to pass, and the roads are kept perfectly clean and free of debris on both sides. One of the parallel entries is a traveling road, free of trolley wires and other equipment, so that employes are not required to go to and from their work in the haulage way. Nevertheless, refuge stations are opened every few feet on the haulage road, together with openings, leading into the independent manway.

About one-third of the coal is at present mined by machines, or 70,400 tons out of the 210,400 produced in April, 1909, and this percentage is being steadily increased by the installation of additional machines. The coal not mined by the machines is undercut by hand pick. The standard mine car used is of wood or steel, holding 93 cubic feet, and running on 40 and 60 pound steel rails on the main haulage roads, with a 48-inch gauge. Electric locomotives of several types are used for haulage.

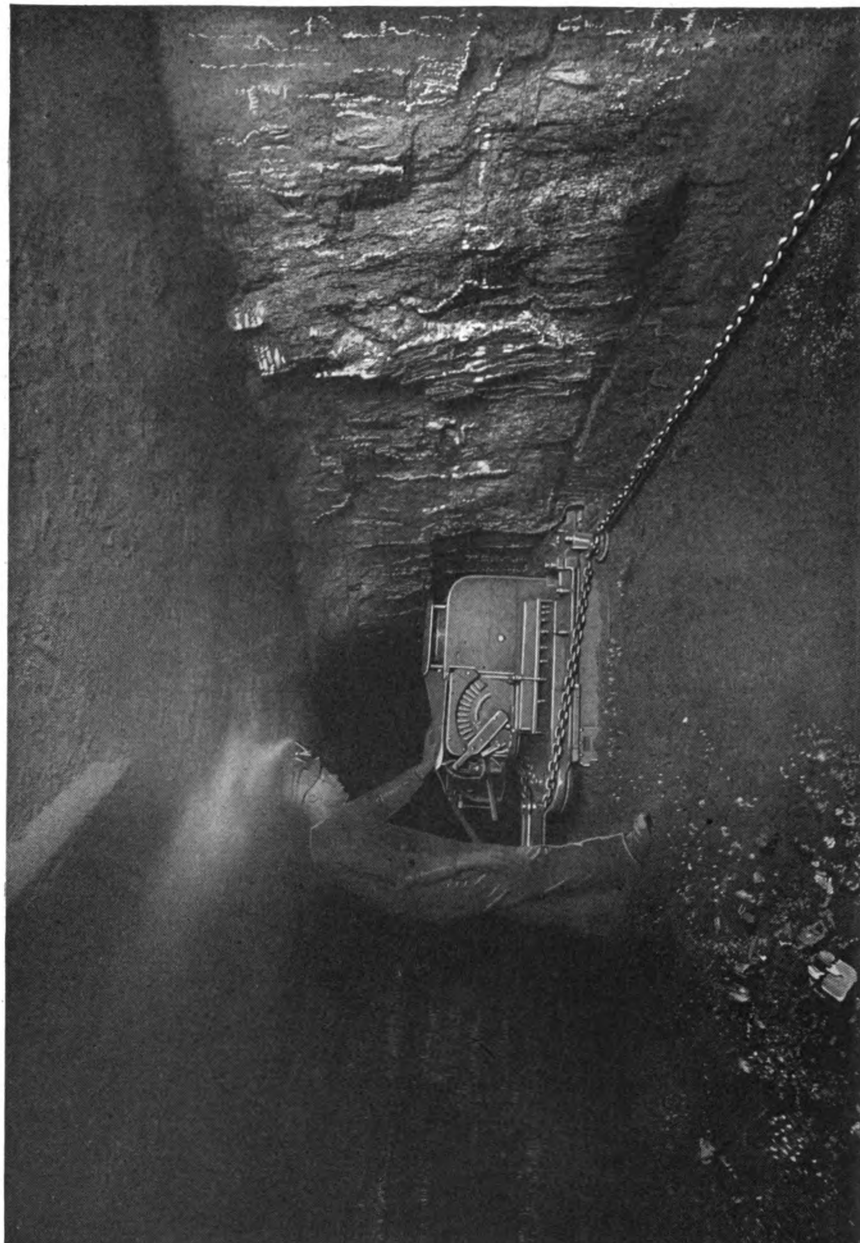
MINING MACHINES

The management first installed machines in the fall of 1906, to enlarge production during a period of labor scarcity. Mining machines of various patterns were tested, and the Sullivan Class "CE" contínous cutting electric chain type was finally adopted as standard, owing to its high cutting capacity and ease of operation.

These coal cutters, of which the company has now over 40, with a number more on order, make a mining 6 feet 6 inches deep, and 5½ inches high. They are designed to cut from left to right or from right to left, depending on the location of the track in the room. The armatures are wound for the uniform underground current of 250 volts. The accompanying photographs, taken in No. 3 mine, show these machines, and several stages in their operation. It will be noted that after the rib cut is made, the rear half of the frame is uncoupled, and the jacks set in opposite corners of the room. The machine then travels across the face like a long wall cutter, under its own power, making a continuous mining. This type occupies less than six feet at right angles to the face of the coal, so that it is unnecessary to take down and replace props to permit its passage. The small space occupied by the machine also makes lighter work for the loaders.

These machines are used for driving entries, room necks and break-throughs as well as for mining in rooms. They are moved from place to place on self-propelling trucks, and perform all operations of loading, unloading, etc., under their own power. The cutting is all done at night and the loading in the day time. This arrangement prevents the interference of coal haulers with machines as they go from place to place, and at the same time gives both the machines and the electric haulage locomotives plenty of current at all times.

The average work during April for 27 machines was 7½ places or about 120 tons per machine per 10-hour shift, although some individual records made were much in excess of this average.



Sullivan Electric Chain Machine crossing the face of a room from left to right, under its own power.

SURFACE PLANT

The photograph on page 312A shows the tipple at No. 10 mine, which is typical of those in general use. These structures are built of steel, with modern devices for handling the coal as it comes from the mines. Coal for the ovens goes through crushers and then into large storage bins, from which the coke larries are charged.

At each tipple there are also steel chutes for loading into the railroad cars. The ovens are equipped with large doors and wide yards to permit the use of coke-drawing machines. Twelve of these are used, pulling about 65 per cent. of the coke from the company's ovens.

The ventilating fans are of the most efficient type, adequate for forcing air to the extreme limits of all the workings, and are substantially set in solid concrete buildings.

POWER EQUIPMENT

The central power plant from which all the 12 mines are operated, is at Gary, adjoining Mine No. 3. The boiler house contains nine horizontal, water-tube boilers, giving a total horse power of about 3,800. The furnaces are charged automatically by underfeed stokers, supplied from overhead steel bins.

In the engine room are two 400 kilowatt generators direct connected to cross compound Harrisburg engines and two 750 kilowatt generators, direct connected to Allis-Chalmers Corliss cross-compound engines; also one 1,000 kilowatt low pressure, and one 1,000 high pressure turbo-generator, the former taking its steam supply from the reciprocating engine exhausts.

These units generate three-phase, 25 cycle alternating current at 6600 volts, which is transmitted to sub-stations at each mine, and there altered to 275 and 250 volts d. c. for the mining machines, pumps, and locomotives, by rotary converters and transformers.

The machine and forge shops are well equipped with modern tools for electrical and machine repairs, insuring the rapid and economical work essential for a large industry such as this, far from a source of supplies.

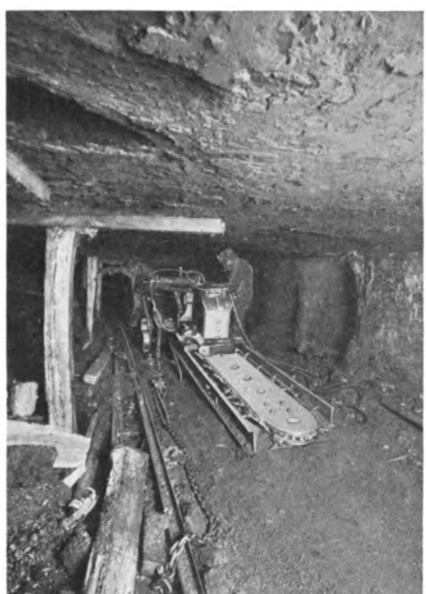
The company's offices, general store, power station and shops are large permanent stone buildings, with ample provision for growth.

The town of Gary is well paved, lighted, and has excellent water and sewer systems and fire protection.

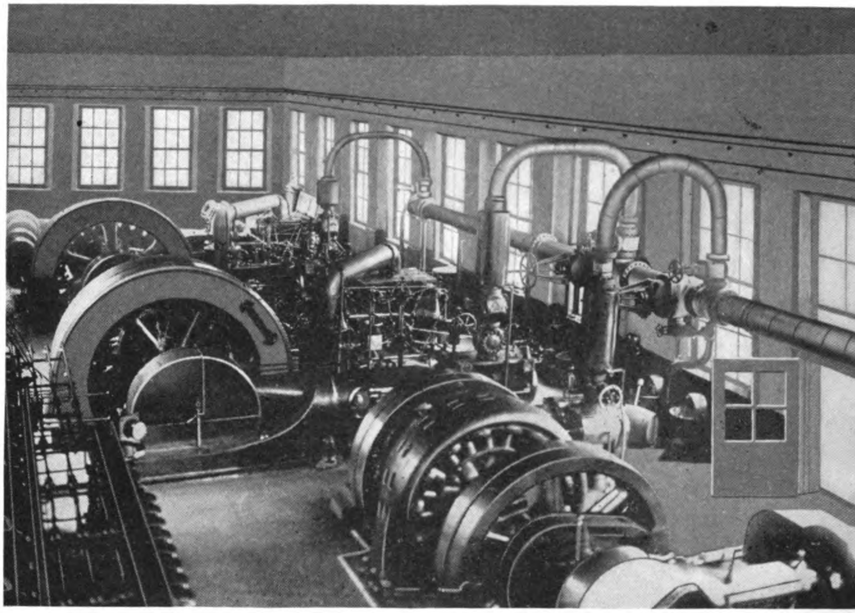
LABOR AND SAFETY PROVISIONS

About 3000 men are employed at the various mines, including a construction force of 300. The employees include Americans, foreigners of several nationalities, and negroes, who live, to a large extent, in substantial houses built and owned by the company.

The U. S. Coal & Coke Company enjoys the distinction of having the best equipped and safest mines in West Virginia. Under the administration of Mr. Thomas Lynch, president of this company, as well as of the Frick Coal and Coke Co., a remarkable record of freedom from acci-



Sullivan Machine unloading from its truck.



Interior of Central Power Plant.

dent has been made. During the year 1907, the mines under his administration produced over 18,000,000 tons of coal, ranking them first among the coal mining companies of the world. In eighteen years these mines have not lost a life by a gas or dust explosion. At Gary, all the mines are supplied with a carefully drawn set of rules, regarding ventilating and sanitary conditions. These are printed in seven or eight languages in large type, and posted in conspicuous places. Particular attention is called to the necessity for careful handling of powder. It is required that not more than a certain number of men shall work in any one air current, and that the current shall not fall below a stipulated velocity or a quantity of 10,000 cubic feet per minute at any point throughout the entire mine workings.

The mine foremen, assistant mine foremen, and minor officials are paid premiums each month during which no one under their jurisdiction is seriously injured. Since the adoption of this method, accidents of all classes have been reduced more than one half. Premiums are also paid to the superintendents, who keep their plants in the best and neatest order, also to householders, for the best kept yards and gardens. All mine officials are required to pass a physical and mental examination as to their eyesight, hearing, and reasonable discretionary powers, before appointment to duty. In the main office at Gary a set of rescue apparatus is installed for use at the various mines in case of emergency.

The records show that in spite of the fact that the country being developed is entirely new, and the subordinate officials are strange to their positions, the number of accidents for the miners employed is the least, not only in the state, but in any other state as well, or in any other country. As was noted above, all the coal in these mines is undercut before being shot. No shooting from the solid is permitted, and men are employed to see that the coal is properly mined before

shooting, thus eliminating the great danger to life from shooting off the solid, to say nothing of the amount of powder-smoke done away with.

CORE DRILLING IN NOVA SCOTIA

Since 1900 the Department of Mines of Nova Scotia has owned and operated several prospecting core drills to further the interests of the mining industry in that province.

As this is one of the few instances in which costs of drilling work are available to the outsider, the carefully compiled published reports of the department are always interesting. That for the year ending September 30, 1908, has recently appeared. The department had five drills in use during the year, two of the Sullivan Diamond pattern, and three of the Calyx shot type. During the year these drills bored 22 holes for a total of 7,905 feet 7 inches, some 1,600 feet in excess of the work for the preceding year, and the largest amount of work thus far accomplished per year.

The cost per foot for all boring by diamond drills was 80½ cents, and by Calyx drills $1.34. The carbon cost per foot in boring by diamond drills was $.077, and the shot cost per foot by Calyx drills, $.056. These costs compared with last year's results were as follows:

Cost per foot, all boring, 1907, $1.23; 1908, $1.06, Decrease 17 cents.

Cost per foot, Calyx, 1907, $1.71; 1908, $1.34, Decrease 31 cents.

Cost per foot, Diamond, 1907, $.73; 1908, $.845; Increase 11 cents.

Shot cost per foot, Calyx, 1907, $.047; 1908, $.056; Increase $.009.

Carbon cost per foot, Diamond, 1907, $.0129; 1908, $.077; Increase $.041.

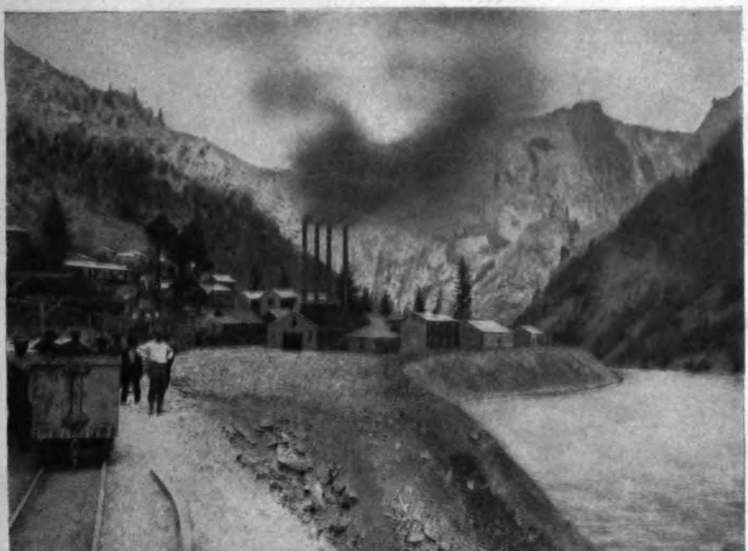
The article on "Test Borings for Dams and Bridges," which was announced for this issue of "Mine and Quarry," has been omitted owing to lack of space. It will appear in the next number.

Tipple at No. 10 Mine, Gary.

R. R. DONNELLEY & SONS CO., PRINTERS.

MINE AND QUARRY

VOL. IV, No. 2. SEPTEMBER, 1909.

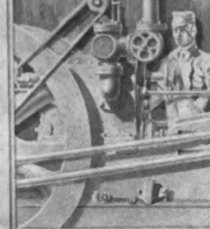


RIVER PORTAL POWER PLANT IN THE GUNNISON CAÑON

THE GUNNISON TUNNEL

VENTILATION AT AN INDIANA COLLIERY

QUARRYING MARBLE IN TENNESSEE



PUBLISHED BY THE SULLIVAN MACHINERY CO. RAILWAY EXCHANGE BUILDING, CHICAGO.

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MINE AND QUARRY

Vol. IV. No. 2 SEPTEMBER, 1909.

A Quarterly Magazine of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

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Readers are requested to notify MINE AND QUARRY of any correction or change in address.

Many thanks to those readers who have kindly expressed appreciation of "Mine and Quarry." It is the aim of the editors to provide some article in each issue which may be of interest or value to each industry represented upon the mailing list. At the same time, that list is now so varied in its scope, and space so limited, that all interests cannot be exactly supplied at once. The editors ask indulgence for such deficiencies, which are avoided so far as practicable.

From Los Angeles comes word of a new world's record in tunnel driving. One heading of the Red Rock tunnel of the Los Angeles aqueduct was advanced 1,061.6 feet during August. The material is, from the data available, a free-drilling sandstone. The previous record, 1,013 feet, was made in July, in the Swiss Loetschberg tunnel. Among American tunnels the record had been held by the west heading of the Gunnison Tunnel, 824 feet in black shale, as mentioned elsewhere in this issue. Without complete and exact information concerning local conditions, an analysis of these records is impossible. To quote Project Engineer McConnell of the U. S. Reclamation Service, "If any lesson can be gained from bare statements of tunnel progress it is the utter folly of comparing organizations by the number of feet of advance made in a given time. Conditions at the heading control absolutely. For instance, the same organization which made 824 feet in dry shale in one month found itself very much more self-congratulatory over a 50 -foot progress in a month in the fault zone. It may be entertaining to note that from the time of opening the portals to the meeting in July 6, 1909, the average progress for all headings was 566 feet per month, or, counting the whole number of "gang-months," 255 feet per gang per month. (Gunnison Tunnel).

The advantages of air power as compared with steam have long been appreciated in the mining industry. In construction work, which is usually carried on in the open air, so that there is no physical drawback to the use of steam, air, while gaining numerous converts in the recent years, has been obliged to contend with the popular prejudice against untried methods, and the injury done it by uneconomical early installations. Mr. Frank Richards, in The Barge Canal Bulletin, a publication of the New York State engineering department, takes up the cudgels for air power in a convincing article. In addition to the instances therein cited, at least one more may be referred to, as illustrating concretely the advantages and economy of a central compressed air power plant, for operating scattered machines of various kinds on a large construction enterprise. The following paragraphs are taken from a description of the plant and methods used in building the great dam of the McCall Ferry (Penna.) Power Co., on the Susquehanna River.

"Air power from the central compressor plant has been used in all feasible ways, from the very beginning of this under-

taking. In the excavations which were necessary to give the dam a solid rock foundation in the river bed, and in the blasting work in the tail race, standard Sullivan air-driven rock drills were used. In the erection of the cofferdam cribs, which are built of immense timbers spiked together, the holes for the spikes are bored with air-driven augers. The concrete mixer, consisting of eight units, each with its own engine, is run entirely by air power.

"For depositing the concrete in place along the dam there are five huge traveling pelicans, two of which have two engines each, and three, four each. Besides these, there are at work at various points along the dam five derricks of five tons capacity each. There is also a thirteen-hundred-foot cableway, capable of handling a five-ton load. The engines on all this machinery are operated by compressed air.

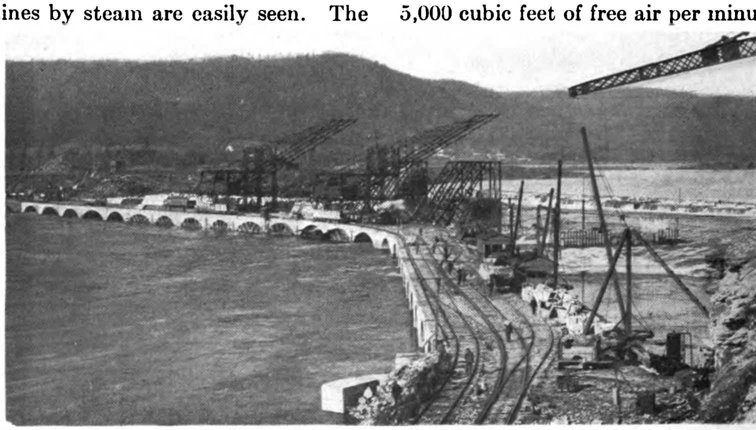
"In the machine shop, where the repair work is done and the spikes and bolts used in construction are made, as well as in the carpenter shop, where the cement forms are built, the power is derived from an engine driven by compressed air. An eight-hundred-pound steam hammer in the machine shop is also worked very successfully by air power.

"The advantages of this method over that of running so many scattered machines by steam are easily seen. The cost of producing the requisite amount of air with compressors of the Corliss cross compound condensing type, developing a horse-power on from 14 to 16 pounds of feed water per hour, and the resulting low fuel consumption, is much less than the cost of steam to do the same work. The loss in transmission of air power is very slight as compared with the loss due to condensation in steam pipes. An expensive system of distribution of water and coal is avoided. Individual boilers for the hoisting engines, as well as firemen to tend them, are dispensed with. Repairs on such boilers, which would be great owing to the inferior class of labor necessarily employed, are saved. The increased comfort to the men arising from the absence of heated parts about the machines, greatly facilitates the progress of the work.

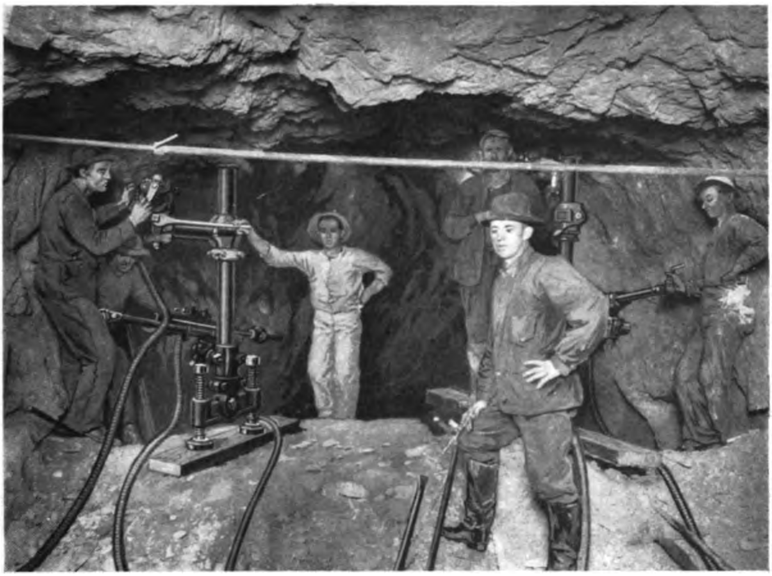
"Such have been the demands of the work that since the compressors at the dam were installed in May, 1906, they have frequently had to run during the entire 24 hours for several days at a time, yet at no period has the work been held up for want of air pressure, and the cost of repairs has been practically nothing."*

The air power plant mentioned consisted of two Sullivan-Corliss cross compound steam and two-stage air compressors, having a combined capacity of over 5,000 cubic feet of free air per minute.

The McCall Ferry Dam Under Construction.



*Mine and Quarry, August, 1907



Sullivan "UD" Drills in the River Portal Heading of the Gunnison Tunnel.

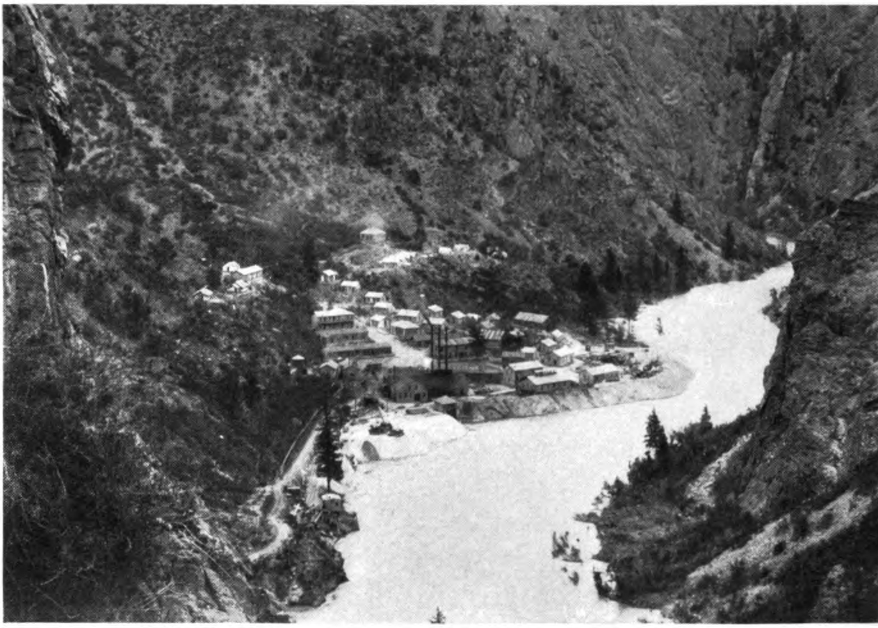
THE GUNNISON TUNNEL

By W. P. J. Dinsmoor*

On July 6th connection was made between the eastern and western headings in the Gunnison tunnel, of the Uncompahgre Irrigation Project of the United States Reclamation Service, in Montrose County, Colorado. The culmination of four and one-half years' work in driving the longest tunnel in America (30,582 feet) is thus described in the report of Mr. C. T. Pease, the Project Engineer:

"On Tuesday morning, the 6th, Mr. Daniels broke into West Portal heading with an 18-foot drill hole and at 11 o'clock a blast at the River Portal end reduced the distance between headings to fourteen feet. The crews at both headings were, of course, making every effort to be the first to break through. During the day, up to 4 o'clock in the afternoon, the crew at West Portal put in a round of eleven 10-foot holes. These were heavily loaded and fired at about 5 o'clock, in the hope that the heading would be broken down, but when the smoke cleared away it was found that there still remained about four feet of wall between the headings. Fortunately, four of the holes drilled near the center of the round did not break to their full depths. The heading crew immediately reloaded these holes as heavily as possible and fired at about 5:30. This shot so shattered the remaining wall that with the use of a pick a small hole was excavated and one of the drillmen pushed through. As the second man attempted to make a passage the crew at East Portal discovered him and in a good-natured rivalry to have one of their own crew the first through the hole attempted to drive him back with the air hose. In this they were unsuccessful. Messrs. McConnell and Hardy made their way to River Portal camp and took supper with Mr. Daniels.

* 1748 Broadway, Denver, Colo.



The Gunnison River and Power Plant at River Portal. A small cross in the left foreground indicates the tunnel entrance.

The Uncompaghre Valley, town of Lujane, and west portal of the tunnel.

"The honors appear to be fairly well divided, Mr. Daniels having been the first to open communication between the two headings and Mr. McConnell the first to open a passageway."

The drill steel that first connected the two headings is kept as a valued memento of the occasion.

This undertaking will divert water from the Gunnison River to the Uncompahgre Valley, there furnishing a regular supply to about 150,000 acres of what is expected to beome the best farm land in Colorado· To do this it has been necessary to pierce a mountain 2,200 feet in height, above the river level, with a bore 10x12 feet in size, giving a capacity of 1,300 cubic feet of water per second. The river end of the tunnel is 62 feet higher than the lower or western end.

HISTORY OF THE WORK

This enterprise is remarkable in many ways besides that of its magnitude. Begun in February, 1905, the contractor made so little progress during the first year that in February, 1906, the Government engineers took over the job and have since carried it through by force account. Too much credit cannot be given them for their skill in solving the physical problems encountered, their thoroughness in building up and maintaining a working organization, and their energy and patience in prosecuting the enterprise and overcoming difficulties.

Since the Government took charge of the work of driving this tunnel, the project has been in charge of Mr. I. W. McConnell, up to the time of his appointment to another position in the Reclamation Service, and since that time in charge of Mr. C. T. Pease. During the construction under the Government the work at the River Portal has been under the direct supervision of Mr. W. H. Davis, who was succeeded later by Mr. H. L. Daniels as superintendent, while on the West Portal the superintendents have been Mr. C. E. Higbee, Mr. A. F. Ross and Mr. L. A. McConnell, a brother of Mr. I. W. McConnell.

UNUSUAL DIFFICULTIES

In piercing the divide known as Vernal Mesa nearly every variety of formation and every trouble known to tunnel engineers were encountered. At the western end the work was at first through alluvial soil, then in shale and gravel, carrying large quantities of water. For 10,000 feet the tunnel ran through black shale, containing pockets of inflammable gas. At about the center, for a distance of nearly half a mile, a zone of geologic faults was penetrated, which, according to an article by Mr. I. W. McConnell, recently published, "furnished a weird and unholy assortment of grief. Working in a saturated atmosphere at a temperature above 90 degrees Fahrenheit, the workmen were obliged to exercise the utmost caution to prevent fatalities to themselves. At frequent intervals rushes of water would break in from the sides or face, carrying in hundreds of yards of sand, which buried tracks, tools and everything else for 500 or 600 feet from the breast. Seams of hard, blocky ground were underlaid by beds of disintegrated sandstone, which would let loose without warning and threaten the safety of the entire heading force. In one instance a rush of water under foot loosened the drill columns in the heading by scouring out the sandy bench underneath.

"A mile from the nearest point of egress, threatened by water and gas and weakened by the stifling heat, the timid workman soon deserted. To the men who know the difficulties of this period and contended with them, the supreme courage of the workingmen who stood by the work and sweltered in those dubious surroundings will always be a subject of deep gratification.

"After nearly a year of painfully slow and excessively costly work, this ground was passed and the tunnel entered into

the metamorphic granites which constitute the main body of the mountain."

Much of this granite was exceedingly hard and tough. In the River Portal heading, 10,000 feet long, it was necessary for all supplies and material to be handled through one opening. From this came all ventilation, except that provided by the drill exhausts, and through this all water encountered, and there were enormous quantities of it, had to be pumped, owing to the down grade from the portal.

Through the greater part of its length the tunnel was driven on the bench and heading system, but about a year ago extremely large quantities of water were encountered in the River Portal, so that much larger pumps had to be installed and the expense of driving was greatly increased. On this account it was decided to change the method of driving to an under-cut, leaving the top or back to be taken down later. By this means the lower part of the tunnel has been completed in the shortest possible time and the water met in the River Portal end now flows by gravity from the tunnel through the West Portal, and the expense of pumping is done away with. It now remains for the top to be taken down, bringing the tunnel to its full size, and to put in the concrete lining in that portion which has not already been so lined.

DRILLING RECORDS

During the construction of the tunnel, Sullivan Drills have been used almost exclusively in the hard rock. At first Leyner drills were used on the River Portal heading and Jeffrey Coal Drills on the West Portal heading, where extremely soft shale was encountered. Later on Sullivan 3-inch piston drills were used on the River Portal heading and have been used continuously ever since. On the West Portal, after harder rock was reached, Sullivan Class UB 2½-inch piston drills were used for some time, and later on replaced by Sullivan Class UD 3-inch drills as the rock grew still harder, and later still Sullivan Class UF2 3¼-inch drills were used in some of the hardest rock. To quote again from Engineer I. W. McConnell:

"Some very creditable progress records have been made. In the twelve months ending July 1, 1906, Superintendent Higbee drove 7,500 feet of tunnel with one gang composed of three shifts, working in shale. The greatest progress in any month was 824 feet of heading advance, which, so far as the writer is informed, is the greatest advance ever made in tunnel driving.

"In 1905 Superintendent Knowles drove 384 feet of under-cut drift in one month in granite rock. One year later, in the same material, Superintendent W. H. Davis drove 392 feet of full-size tunnel in a month. Some months later Superintendent H. L. Daniels drove 449 feet of heading advance in one month, which at the time was the American record in tunnel driving. In March, 1909, Superintendent L. A. McConnell drove over 400 feet of heading. Superintendent A. F. Ross laid out and installed the power plant at the west end under adverse conditions. Afterwards he carried to successful conclusion the difficult and dangerous work in the fault zone.

"In a general way 300 feet per month in granitic formation, free from unusual difficulties, has been regarded on the job as commendable progress. In the heavy ground 240 feet per month was the customary progress, while in the shale with no unusual obstacles 600 to 750 feet per month was expected."

REMAINING WORK

For the work of taking down the top or roof, left by the under-cut heading, the Sullivan Class UD, (3-in.) drills on the River Portal and the Class UB, (2-½ in.) drills previously used on the West Portal are now being employed. Horizontal holes are drilled by machines mounted on bars and operated from scaffolds,

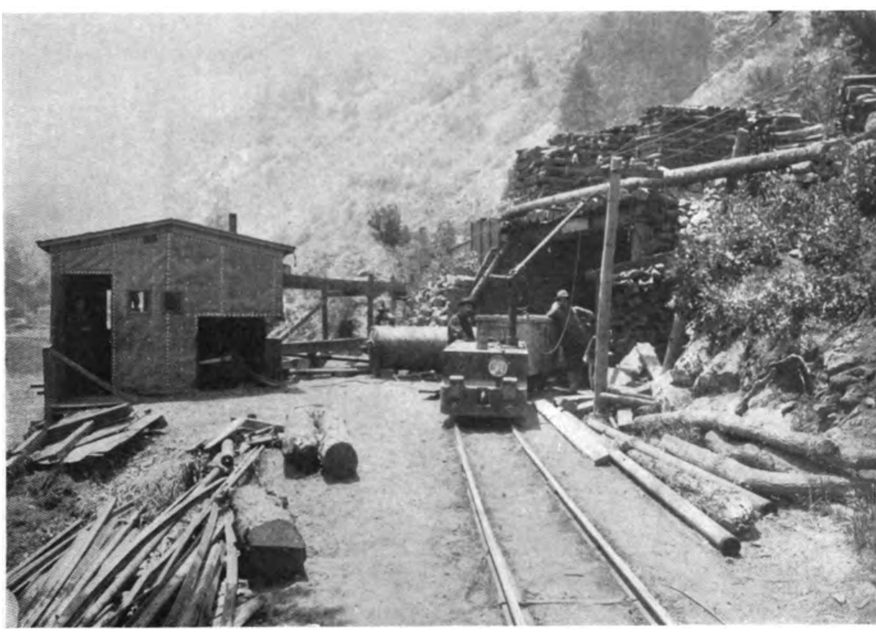
near the top of the finished tunnel, so that, when shot, the alignment of the roof and walls will be maintained. In taking down top by this method, some rock comes down in pieces too large to be easily and economically handled and it is necessary to break these into smaller pieces. For this purpose Sullivan Class DB-15 Hammer Drills are used, putting in shallow holes for pop-shots. The use of this drill, which is primarily designed for quarry work, is comparatively new in Western tunnels, and its success for this purpose will be noted with interest by those connected with tunnel work.

When the tunnel was started in 1905 it was hoped that it would be completed so that Gunnison River water could be turned on to the 150,000 acres of land to be irrigated in the Uncompaghre Valley in the summer of 1908. Many unexpected and unavoidable delays have occurred so that under present circumstances it will be the spring of 1910 before the objects to be obtained from the tunnel can be realized.

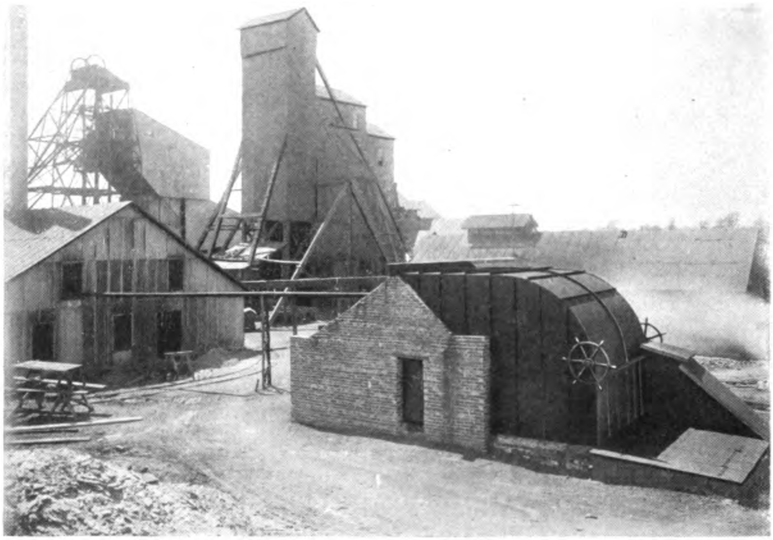
The official opening of the tunnel took place September 22d to 24th, on the occasion of President Taft's visit to Colorado. Active use, however, will not begin until some time later.

The completion of the tunnel will mean the increase in value of many acres of land from practically nothing to hundreds of dollars an acre, and it is not beyond the bounds of possibility to suppose that the marketing of the yield from all these acres, added to the present yield of the neighboring country, will so tax the railroads now operating through difficult mountain passes that the driving of another, possibly greater, tunnel for transportation purposes will be required.

The details of construction and methods employed in this enterprise were described by Mr. M. G. Doll in an article published in "Mine and Quarry" for August, 1906. A very complete article, from which the writer has taken the liberty of quoting, also appeared in the "Engineering Record" for August 28, 1909. This was written by Mr. I. W. McConnell, the first Project Engineer in charge of the work.



Handling Muck at River Portal.



Sullivan Mine Fan and Surface Plant of the Clinton Coal Co., Clinton, Indiana.

VENTILATION AT AN INDIANA COLLIERY

WRITTEN FOR "MINE AND QUARRY" BY M. C. MITCHELL*

The bituminous coal mines of the present day offer ventilation problems which vary greatly from those of a few years ago, owing to the greater extent of mine workings and the changes in method required with increasing tonnage. In former years, when the mines were shallow, the workings limited in area, and the miners few, ventilation was a small consideration. Some mines depended on natural ventilation; others employed small furnaces to create an air current, and later on, as mining progressed, slow-speed fans came into use.

Slow-speed fans were suitable for mines in which it was possible to drive large air-ways, permitting the use of low pressures. In the mines of today, however, slow-speed fans are being replaced by ventilators of high speed and efficiency, better capable of forcing large volumes of air against the high resistance occasioned by long air passages.

MINES OF THE CLINTON COAL CO.

This change in ventilating practice is well exemplified in the Crown Hill Mines of the Clinton Coal Company, at Clinton, Indiana. About eight years ago, the company sunk its No. 1 shaft to what is geologically termed the No. 7 seam, 164 feet from the surface, and five feet thick. They installed at this mine a slow-speed fan, 18 feet in diameter. This gave ample ventilation until about two years ago. By that time the mine was producing about 1,000 tons per day, and the number and length of the air-ways taxed the fan to its full capacity.

At about this time the company put down a shaft to the No. 6 seam, about 340 feet from the surface. This seam is six feet thick. The new shaft, known

*Missouri Trust Building, St. Louis, Mo.

as No. 3, is 100 feet south of No. 1 shaft, and has no connection with it. A ten-foot slow-speed fan was installed to air the new mine. In the meantime, an air-shaft was driven to the No. 6 seam. On its completion, the company erected a Sullivan high-speed, all steel, reversible fan, ten feet in diameter, direct connected to a 14x16 engine.

ONE FAN FOR TWO MINES

The fan was purchased to supply air to both mines at the same time. It is installed near the air-shaft of mine No. 3, and is connected with No. 1 shaft by a concrete tunnel 6x7 feet in size, and about 100 feet long. The manufacturers were then called upon to supply in connection with this fan a device for regulating the amount of air furnished to each shaft. No. 1 mine requires a large volume and offers high resistance, while mine No. 3, being a new opening, needs a comparatively small volume of air, at a low water gauge.

A steel hood was accordingly built in front of the fan, covering the air compartments leading to both mines. Each compartment is fitted with a steel door, the size of the aperture being regulated by sprocket chains operated by hand wheels outside of the hood. These doors can be set to allow any desired volume of air to be thrown into either mine. This hood, with the hand wheels and fire doors protecting the No. 3 shaft, is shown in the photograph on page 320. The tunnel to No. 1 mine is at the right of the hood. This view also shows the power house for both mines, containing the boiler plant, air compressor and hoists.

THE SULLIVAN FAN

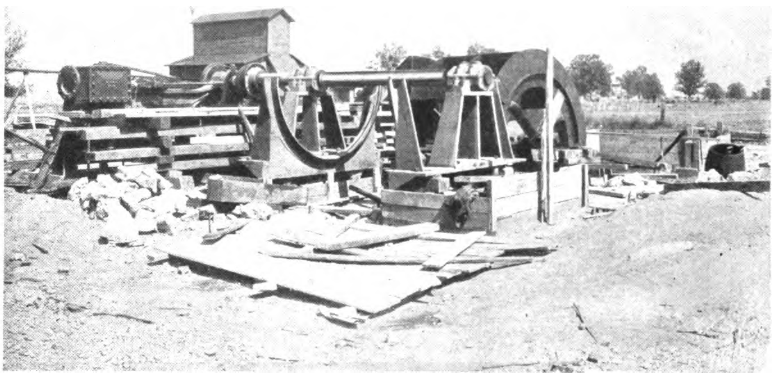
The construction of the fan and the stages in its erection are shown in the photographs on pages 322 and 323. The fan wheel is double. The curved blades or vanes are divided by a central plate, which gives great rigidity to the wheel. Air enters the wheel through a large eye on each side, surrounding the shaft, and is directed out toward the vanes by cone-shaped deflectors, which form part of the connection between the sides and central plate. The wheel is very stiff and substantial, being of steel throughout. The shape and number of the fan blades are designed to give the air the greatest possible momentum or impulse, and thus to pass the maximum amount of air for a given speed under the working conditions.

This fan is unique on account of the method used for changing the direction of the air current. The reversing feature is coming to be regarded more and more generally as essential to safe and efficient mine ventilation. To cite only two advantages, in case of fire or explosion the reversal of the current will retard the progress of flames or gas, while in winter the use of an up-cast current at night in the hoisting shaft, instead of a down-cast, will prevent ice from forming on the hoisting guides.

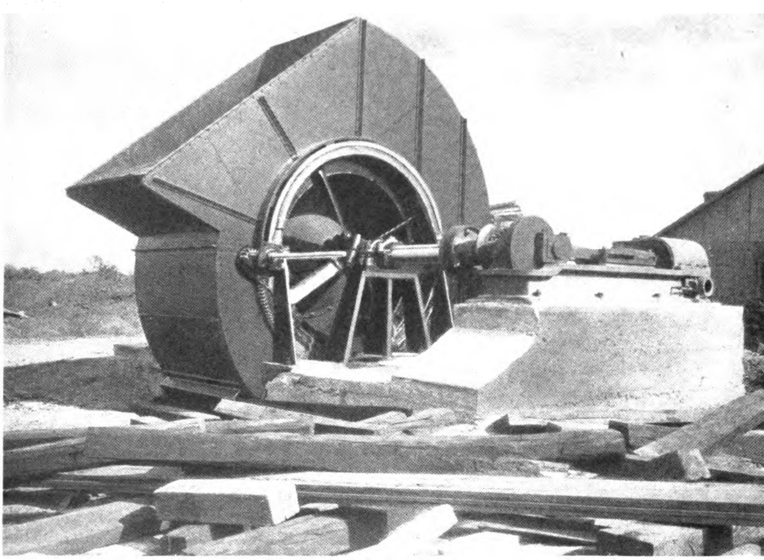
In most ventilating plants the current is reversed by opening or closing certain doors in the air-way, from the fan to the shaft. The operation of at least five of these doors is required, a rather slow and complicated process in case of accident, particularly if the individual acquainted with the proper arrangement of the doors, is not on the spot.

The Crown Hill fan, and others of the Sullivan type, are equipped with a steel hood, as shown at the foot of page 322, which is given a quarter turn when necessary to alter the direction of the air.

For this purpose, the hood is suspended on circular steel plates or rings, and runs on roller bearings. Rotation is secured by a rack on the circumference of the bearing ring, which is engaged by a pinion, turned by a large hand wheel in the engine room. By this means any one about the mine can reverse the current

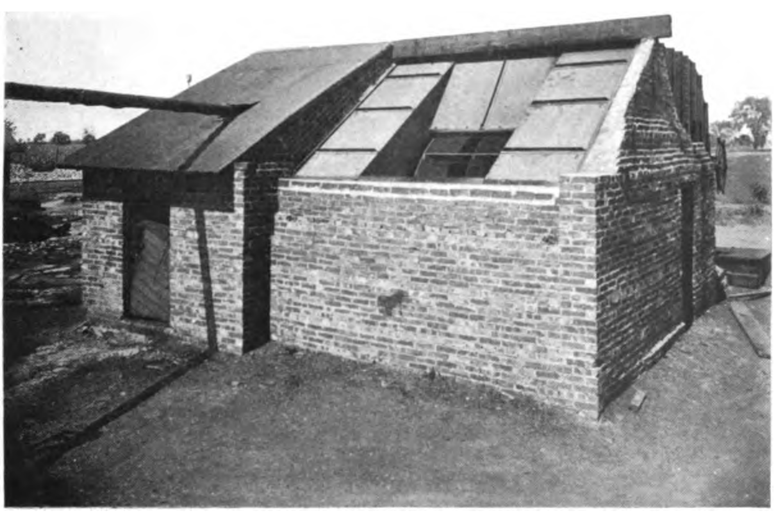


Sullivan Mine Fan in Process of Installation for Crown Hill Mines, Clinton, Indiana.



Fan Complete, with Engine and Hood. The Pinion Shaft for reversing the Hood appears at the left. Hand wheel not yet placed.

Rear of Fan House, showing the Fan blowing air into the mine.



The Fan Running as an Exhauster.

instantly, without stopping the fan. The photograph at the top of page 322, shows the fan shaft and the lower half of the supporting rings or runways in place. On page 323, the upper view shows the fan blowing air into the mine, while in the lower photograph the hood has been rotated, and the fan is drawing air out of the shaft. The lateral wings or plates noticed about the mouth of the hood provide the necessary packing to prevent leakage. Two doors are used, merely to protect the fan in case of an explosion. The foundations are small, as will be seen by reference to the photographs. This installation required about 27 cubic yards of concrete, for the foundations, and about 19,000 bricks for both the engine house and fan house.

PRESENT VENTILATION

The cuts on page 322, show the house covering the old 18-foot fan, which, with the 10-foot fan first placed at the No. 3 shaft, has been shut down ever since the Sullivan fan was set to work. The 18-foot fan was unable, as above noted, to air mine No. 1 properly, while that at mine No. 3 was sufficient for a production of only 200 tons per day. At present the new fan supplies ventilation for 290 men and 17 mules in Mine No. 1, producing 1,200 tons daily, and for 146 men and 9 mules in Mine No. 3, whose present output is 750 tons per day. The air in this mine has a travel of about two miles and has two splits. In No. 1 there are three splits, and about seven miles of air-ways.

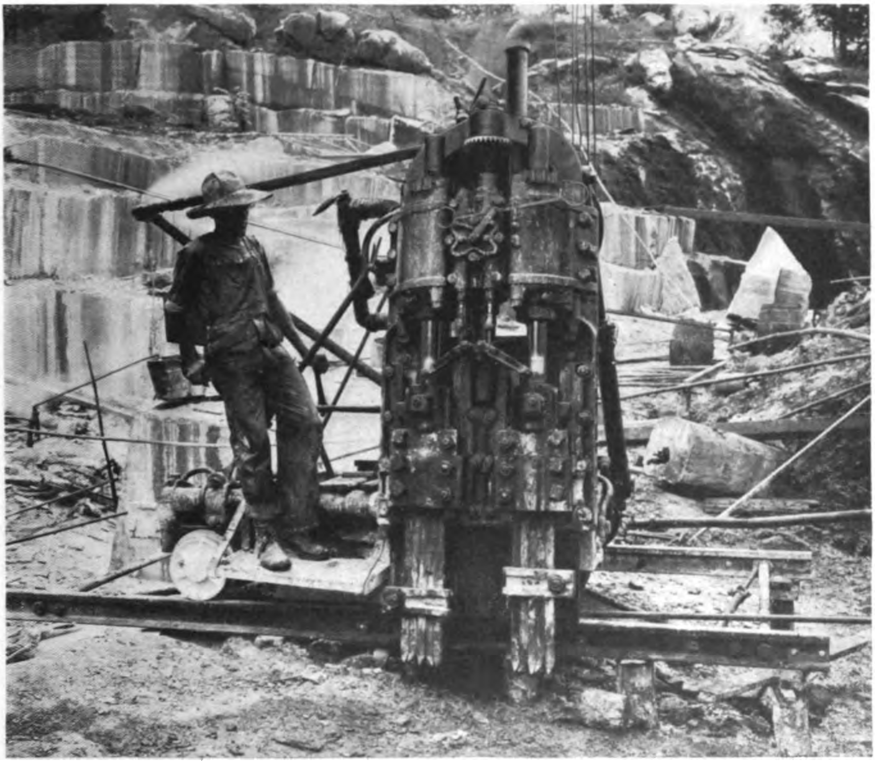
The state law of Indiana requires 100 cubic feet of air per man, and 300 cubic feet per minute for each mule. This is more than cared for by the fan at a speed of 130 revolutions per minute. The fan has been thoroughly tested to learn its efficiency, up to 245 r. p. m. At this speed it moved 154,000 cubic feet of air per minute, against a four-inch water-gauge. It is estimated that the ultimate pressure required in ventilating these mines will never exceed a three-inch water-gauge.

GENERAL MINING FEATURES

The Clinton Coal Company's mines are well equipped in other respects, both on the surface and below ground. Page 321 shows the steel tipple at No. 3 mine and the wooden structure over the old No. 1 shaft.

Electric locomotives were installed about two years ago in No. 1 mine, to gather the cars in trips at the various partings, and haul them to the foot of the shaft. All coal here is mined by hand, but in No. 3, the coal is undercut by 22 Sullivan compressed air pick machines, of the Class 5 pattern, weighing 825 pounds, and cutting to a depth of 5½ feet.

The writer acknowledges the courtesy of Messrs. H. M. Ferguson, General Manager of the Clinton Coal Company, Mr. A. P. Gilmore, Superintendent, and of Messrs D. R. Griffiths and L. Kelley, managers of Nos. 1 and 3 mines, for assistance in preparing this article.



Sullivan Duplex Channeler, Class "VW." in the Friendsville Quarry.

QUARRYING MARBLE IN TENNESSEE

IMPROVED METHODS AND MACHINERY

WRITTEN FOR MINE AND QUARRY BY B. C. HODGSON.*

The Tennessee Marble deposits, situated in Knox, Union, and Blount Counties, within a radius of 20 or 30 miles of Knoxville, differ in numerous respects from those in other parts of the country. Instead of lying in regular, uniform beds, like those in Georgia and Vermont, the Tennessee strata are uneven, particularly at the surface. This is due to geological disturbance, followed by the action of water and the abrasion of glaciers.

The marble crops out in piles of large boulders, separated by wide cracks or mud seams. Frequently, as in the case of the quarry to be described below, the seams gradually close below the surface, approaching a solid formation. This circumstance makes quarrying more costly and uncertain than if the deposits were solid and uniform.

The photograph on page 326, shows a general view of the quarry of the Evans Marble Company, at Friendsville, Tenn., in Blount County, some 20 miles south of Knoxville on the Louisville and Nashville Railroad. The value of the marble secured here more than offsets the difficulties attending its production, The stone is of very fine grain, compact and hard. It is practically a pure carbonate

*Knoxville, Tenn.

Quarry of the Evans Marble Company, Friendsville, Tenn. Sullivan Duplex Channelers at right and left.

of lime (98.78 per cent) and contains only small traces of iron and sulphur, making it an excellent material for all building purposes. It is secured in several handsome shades, pink, however, predominating.

This quarry has been in operation for about fifteen years, and large quantities of valuable marble have been taken from it. A number of blocks were quarried 16x3x3 feet in size on a recent contract.

QUARRY METHODS

The stone is quarried by means of Sullivan Class 6½ and Class VX channelers and Sullivan rock drills, mounted on tripods and quarry bars. The class 6½ channelers have been in use for some twelve years past. The length of the runs in this quarry seldom exceeds twenty feet, and the average depth of the channel cut is six feet, with an occasional ten-foot cut. All the machines are run by steam, with 100 pounds pressure at the throttle.

About six months ago the company, being anxious to increase its production, installed two of the latest type of marble channelers, known as Sullivan "duplex" Class VW machines. As these channelers are a recent development, and have not before been described in these columns, extended mention of them may be in place.

SULLIVAN DUPLEX CHANNELERS

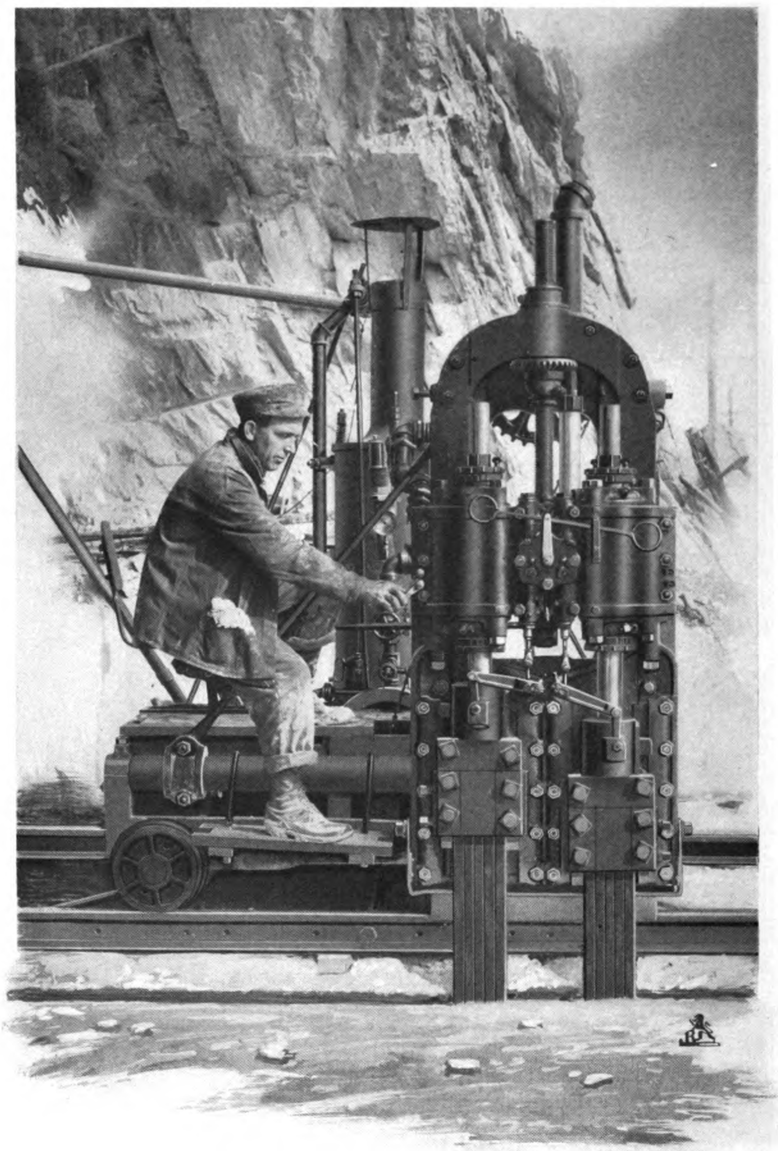
Some four years ago, the manufacturers brought out, at the suggestion of the Georgia Marble Company, a channeler with two direct-acting cutting heads or engines, and two sets of steel or bits. These were mounted one at each end of the frame, on the same side of the machine, working in the same cut or plane. This arrangement is practically two single channelers on one frame, and enables one runner to operate both.

The Georgia Marble Company has placed second heads on practically all its single machines, thereby doubling its cutting capacity, without any material increase in labor. A photograph of one of these machines, of which about fourteen are used, appears on page 329.

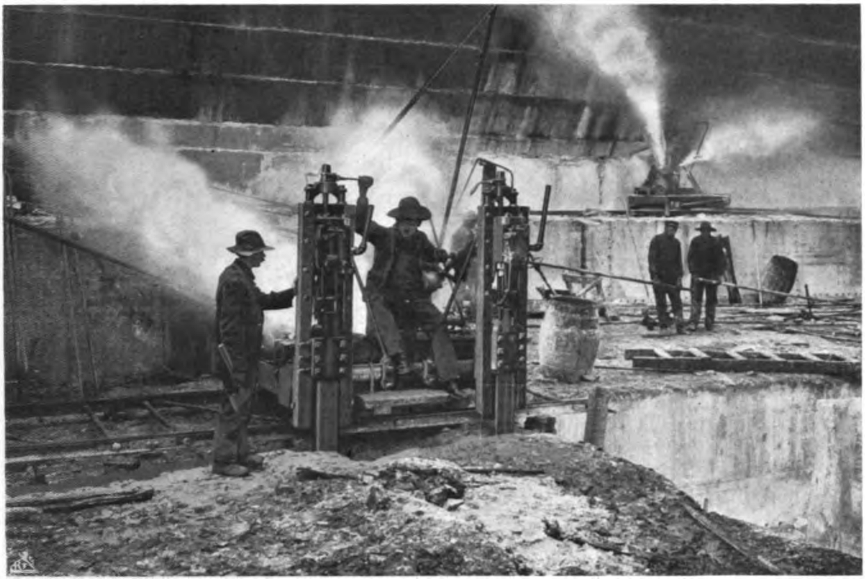
The manufacturers carried out the idea of two cutting heads still further, and about two years ago, placed the perfected "duplex" channeler on the market.

The channeler in question is shown on page 328, while pages 325 and 330 show it in operation. In marble work it is used without a boiler, like the original class 6½ machine. Page 328 shows it equipped with an air reheater. In the Class VW channeler, the two cutting engines are mounted on a single standard, which can be swiveled to cut at any angle, from vertical to horizontal. The principal advantage gained by this arrangement over the "double-head" pattern results from the decrease in vibration. In the latter, the two engines are apt to get "out of step," striking at the same time instead of alternately, thus causing the machine to rock and to throw the channel out of line. The runner has much easier control over the VW channeler than over the "double-head." He is not required to get the engines in step in this case. That is done automatically by a valve motion which drives one gang up while the other is on the down stroke. The engines thus balance each other, so that the channeler runs smoothly and with little jar. It is possible to run the VW engines at a higher speed than either the single or double 6½ channelers.

The reduction in vibration secures important advantages in handling the track, which is much less liable to work out of line with the cut, causing trouble from binding the cutting steels and the consequent wear and tear on the machine. Time is also saved in track shifting, as the rails need not be braced and wedged as firmly as is essential with other types of channelers. This adds much to the actual cutting time during a day's run, particularly when the method of working



Sullivan "Class VW" Duplex Channeler at Work in a Vermont Quarry.



One of fourteen Sullivan "Class 6½" Double Head Channelers in the quarries of the Georgia Marble Company, Tate, Georgia.

the quarry makes short lengths of track necessary.

Ordinarily both gangs are run at the same time, but at any time desired the runner may stop either engine and continue the other alone. This is all conveniently handled from the runner's seat by moving a single handle.

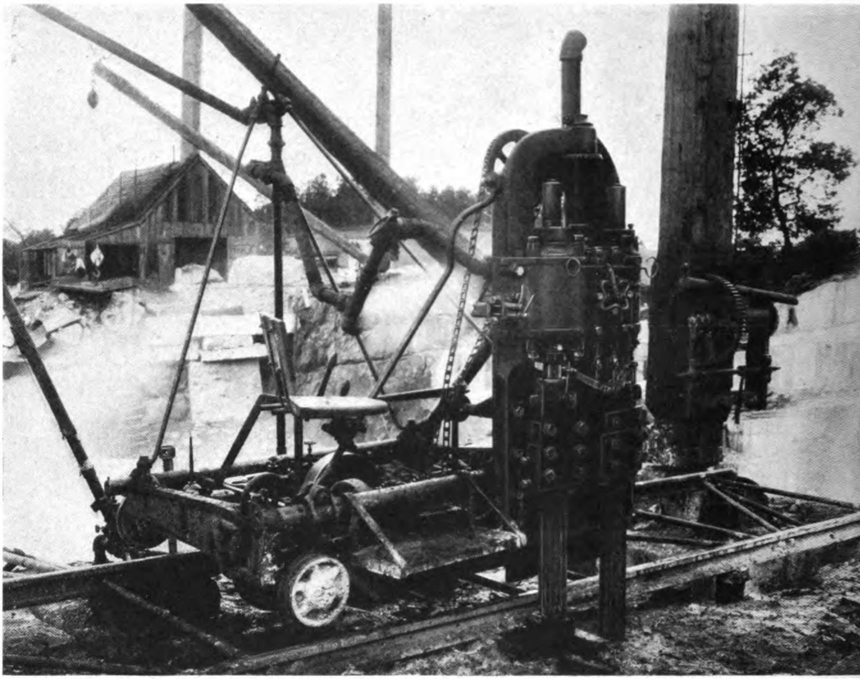
Each cylinder also has its own cushion valve, allowing either or both to be cushioned, as desired. This feature is of value when starting down a cut and in working through a mud seam, to protect the front heads from damage. By means of cut-off valves, the force of the blow delivered by the chopping engines may be regulated to best suit the conditions of the work being done.

The VW duplex machine has been found to be as easy to control, under all conditions, as the single head channeler, and owing to the convenience and simplicity of the controlling devices, and the other features mentioned above, it is very much favored by the channeler runners and helpers.

The duplex channeler is fitted with a feeding mechanism, by means of which the cutting heads are fed downward by power as the cut fleepens, and raised by power to the top of the feed screw at the end of a run. This is accomplished by a sprocket chain drive, operated by a friction clutch on the shaft of the feed engine.

TRACK-SHIFTING

The duplex channeler is, of course, heavier than the single machine. This is not a serious inconvenience, however, as it is moved from place to place in the quarry by means of an improved method of track-shifting. This is indicated in the illustration on page 330. When moving, two screw jacks permanently attached to the rear of the frame are used to raise the machine on that side off the rails. The cutting gangs are then fed down until the wheels on the front side are off the track, thus supporting the channeler on the jacks and steels. It is then easy for two men to shift



A Duplex Channeler Raised from the Rails to Permit Track-shifting.

the track forward to the new position, and the machine is then lowered back onto the rails.

CUTTING CAPACITY

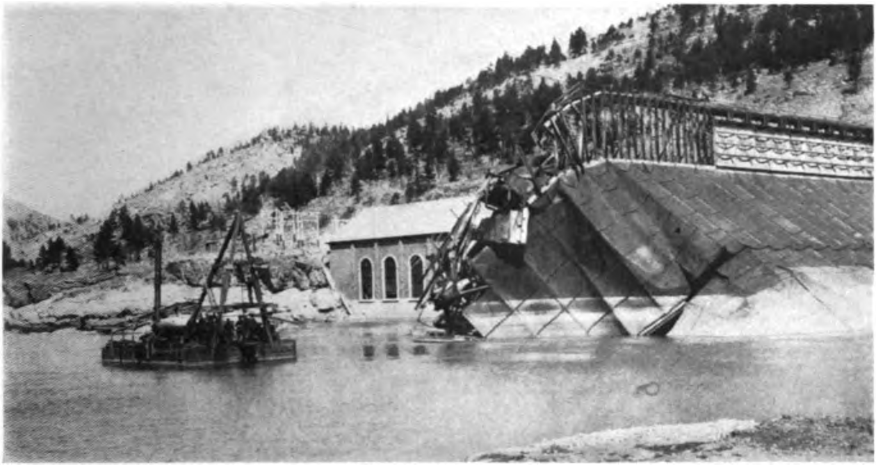
With its class 6½ channelers, the Evans Marble Company averaged 80 square feet of channel per day of ten hours. Under the same conditions the VW channeler cuts on the average 200 feet, while runs of 350 feet have been recorded on various occasions.

It will be noted from these figures that the VW duplex channeler has a capacity more than twice as great as the single head machine, even on runs of no greater length than 20 feet. The increase in efficiency of the VW over two single head channelers would be greater on cuts of greater length.

This excess in capacity, over the work of two single machines is explained by the fact that with the VW two sets of steels are used in doing the same amount of cutting as one set in the single cylinder machine, which means that the steels in the VW machine retain their cutting edge better in running down a length of steel. The mud or sludge is also less of a hindrance, by reason of the greater frequency and alternation of the blows. The other advantages of the VW machine, as above outlined, also contribute to a great extent in the increased cutting capacity.

The home office of the Evans Marble Company is located at Baltimore, Md., with large cutting mills at Baltimore and Knoxville, Tenn. They operate several quarries in the Knoxville marble district.

The writer is indebted to Mr. E. N. Willard, manager, and Mr. R. F. Young, Superintendent for information and aid in preparing this article.



Diamond Drill Scow. Power House and Wreck of Dam, Hauser Lake.

TEST BORINGS FOR DAMS AND BRIDGES

A highway bridge at Peoria, Illinois, across the Illinois river recently collapsed. The failure was due to the scour of the river around and under the pile footings of the piers. These piles were supposed to have been sunk to solid rock. In fact, borings, made for the purpose, had indicated rock bottom.

The borings were made with a churn drill, and the engineers' opinion that bed rock had been reached, was based on the chips and cuttings, washed up in the ordinary way. Aside from the unwisdom of driving piles through rock strata and boulders this instance is one of many which have demonstrated that wash borings cannot be relied on to show the location and extent of mineral formations. In the October, 1908 issue of this paper, Mr. F. H. Bainbridge, resident engineer of the Chicago and Northwestern Railway at Clinton, Iowa, described the methods used to locate bed rock for the foundations of a new bridge across the Mississippi. The accompanying diagram is reproduced from that article. In it the dotted line shows the bed rock as indicated by wash borings with a churn drill, while the full line shows the true ledge located by diamond drill cores.

Experience has shown that a core of all materials penetrated is the only sure evidence that rock encountered is not a boulder or an over-hanging shelf.

The city of Austin, Texas, had an experience of this sort a few years ago. A water supply dam on the Colorado river gave way, a large section of it being carried bodily down stream. Subsequent diamond drill work showed that the dam had been built immediately over a geologic joint or fault and on permeable rock strata which allowed the water to undermine the foundations.

In the spring of 1908, an unusually heavy freshet on the upper Missouri river washed out the Hauser Lake Dam of the United Missouri River Power Co. Diamond drill borings again demonstrated that the dam had been built in an unsafe place, and a new site is now being selected. Near Wolf Creek, some 20 miles further down the river, other boring has been done for a second plant.

The Austin and Missouri river drilling work was accomplished very largely from

scows in the rivers, and was executed under contract for the engineers by the Sullivan Machinery Co. A brief description of the methods used may be of interest to those contemplating similar work.

AUSTIN DRILLING

The test work at Austin, Texas, was done for the Austin Water, Light and Power Commission in the summer of 1908, under the direction of Walter G. Kirkpatrick, M. Am. Soc. C. E., of Jackson, Miss.

The river at this point, some two miles above the city, is about 300 feet wide, and runs between limestone banks, from 40 to 75 feet high. The old dam was 1,091 feet long and 60 feet high, and was washed out in 1900.

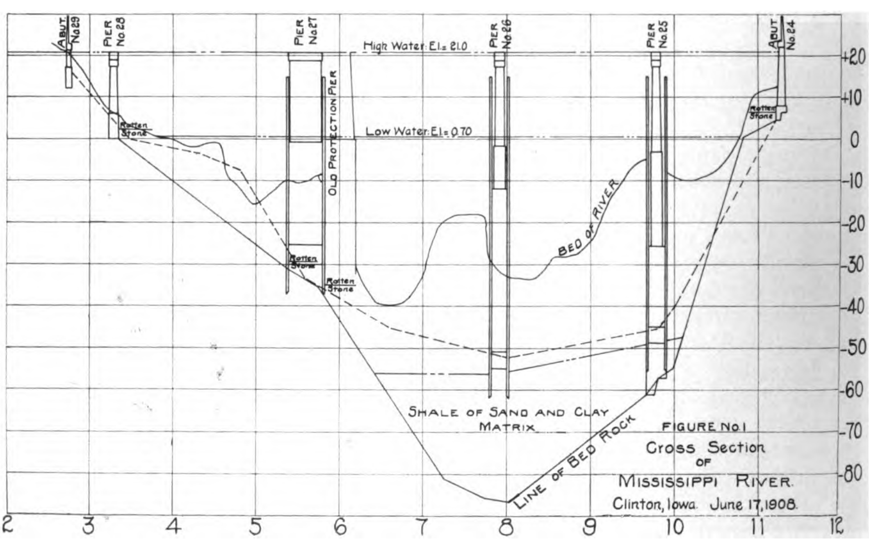
The drill used was a Sullivan "Class HN," capacity 500 feet, removing a two-inch core. Between 25 and 30 holes were bored at intervals of 20 feet in two lines, 20 feet apart. The borings were continued on both banks, and at least one hole, 150 to 200 feet deep, was sunk on each side, to determine the extent of the formation.

The holes bored from the surface of the river ran from 30 to 50 feet in depth. While the work was in progress, the water ranged from three feet six inches deep near the banks to fifteen feet, the average depth being about ten feet.

The manner of handling the drilling outfit was somewhat different from that employed by Mr. Bainbridge on his Mississippi river work. The drilling scow was 20 feet long by 12 feet wide, with a draught of about two feet.

The diamond drill was mounted on one side of the scow, on an overhanging platform, with an improvised tripod for hoisting the pipe and drill rods. The boiler occupied one end of the scow, and the pump and other equipment the other. When the scow reached the proper location pipe spuds set at each corner were lowered to the river bottom and the boat jacked up a few inches on these supports. This process took the weight of the scow off the running water and threw it upon the pipes, so that the drill rested on a firm foundation.

When the operation was reversed the hull was allowed to settle into the water, the pipes raised from the bottom, and the



scow towed to the site of the next hole. In only one instance was it necessary to leave a hole before completion. In this case, the water rose two feet in less than an hour, requiring the drill men to uncouple the machine and tow the boat up against the face of the old dam for safety. The standpipe was left in the hole and drilling was resumed later without losing the work already done.

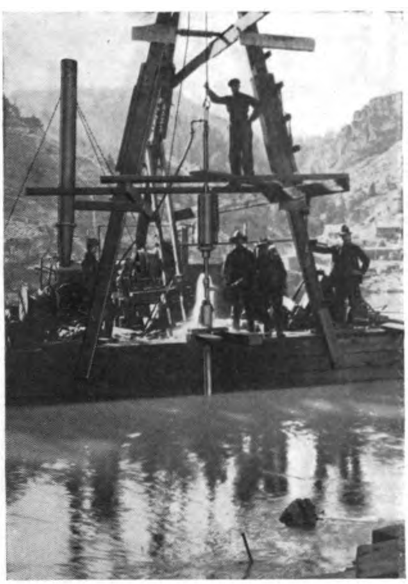
The results of the drilling showed a hard, solid bed of limestone at a depth of 30 to 40 feet below low water level. Above that point were found alternating hard and very soft chalky layers, interspersed with cavities, and overlain with a deposit of boulders, broken rock, gravel, clay and sand. It is believed that the old dam was weakened by leakage of water through these layers, and through the fault referred to, so that when the high water came, the dam and the rock just below it slid and settled at the same time.

HAUSER LAKE DRILLING

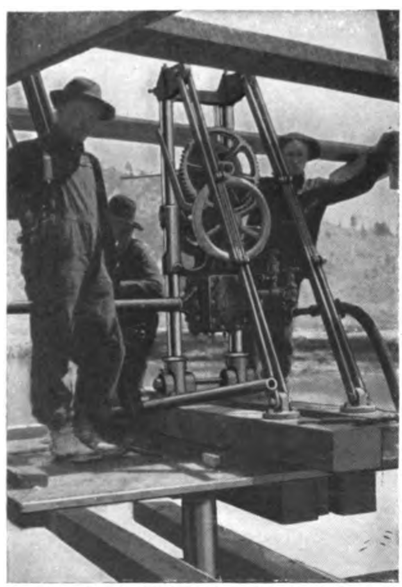
The photographs with which this article is illustrated, show the diamond drill outfits, and phases of the drilling work, on the site of the old Hauser Lake Dam which was wrecked April 30, 1908. The Stone and Webster Engineering Corporation are consulting and contracting engineers, in charge of reconstruction for the United Missouri River Power Co.

Drilling was begun about August 15, 1908, and has continued intermittently until the present. The conditions here were more difficult for drilling owing to the greater depth of the water and the swiftness of the current.

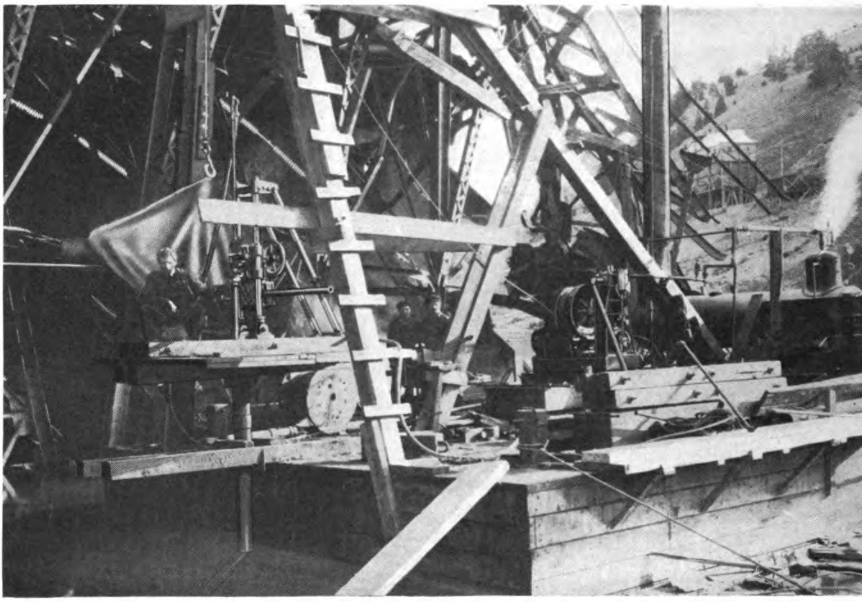
The scow used at Hauser Lake last fall, and a similar one recently at Wolf Creek were 40x24 feet by four deep. The photograph on page 334, shows the scow and drill at Wolf Creek. That on page 334, gives a better idea of the methods employed. The first step, after arrival at the site of a hole, was to sink stand pipe to solid rock, using a class "N" drill for the purpose, as shown below. Six inch casing was driven through the overburden to the rock. This pipe was guyed securely by anchors and cables.



Sinking Stand-pipe, Hauser Lake Site.



Sullivan "Badger" Drill; a detail of the drill and platform.



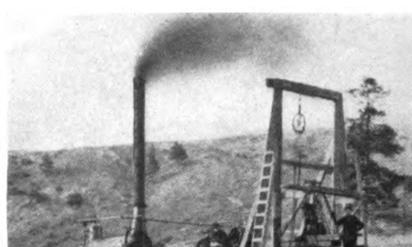
Sullivan "Badger" Diamond Drill on six-inch Standpipe. "N" Drill Engine and Drum at right. Wreck of Dam in background.

The Badger drill was then mounted over the 6 inch pipe on a platform clamped to it as shown on page 333. Size "A" bits, rods, etc., are used for the actual core drilling, removing a $1\frac{1}{8}$ inch core. The hoisting of rods was done with the "N" engines as shown on this page.

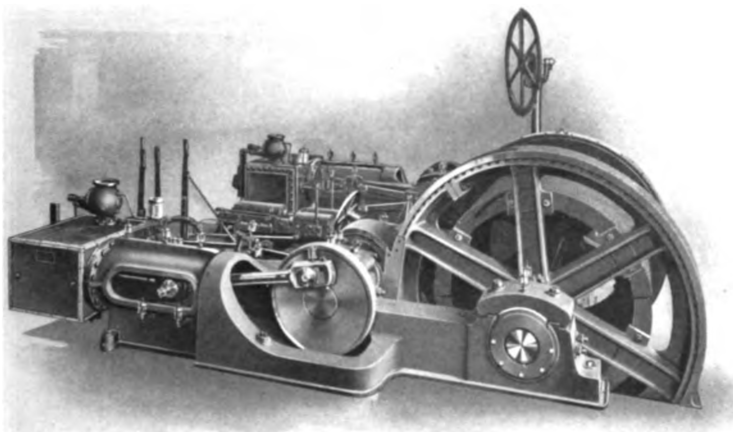
The six-inch pipe affords a steady foundation for the drill, so that the latter is not affected by changes in water level or by the current. The water averaged 35 feet deep at the Hauser Lake site, so that jacking up the scow on spuds or pipes, resting on the river bottom was out of the question.

About 25 holes were bored at the Hauser Lake site. They were sunk 16 feet into bed rock, and established the presence of a flinty ledge, without deep holes or depressions, about 55 feet below mean water level.

The Sullivan Machinery Co. has also under contract a large amount of drilling for the Canadian government on the site of the Quebec bridge across the St. Lawrence river. The same methods are employed there as in Montana. This bridge is to replace the one which failed during construction in September 1907, due to faulty design of the superstructure. The Canadian engineers are determined to take all possible precautions against failure in this fresh undertaking; hence the diamond drill borings.



Diamond Drill outfit at Wolf Creek Site.



Sullivan Automatic Slide Valve Hoist, side view.

A NEW HOISTING ENGINE

The Cleveland Cliffs Iron Company has recently installed a hoisting engine at its Lake Shaft, near Ishpeming, Michigan, which comprises some unusual features.

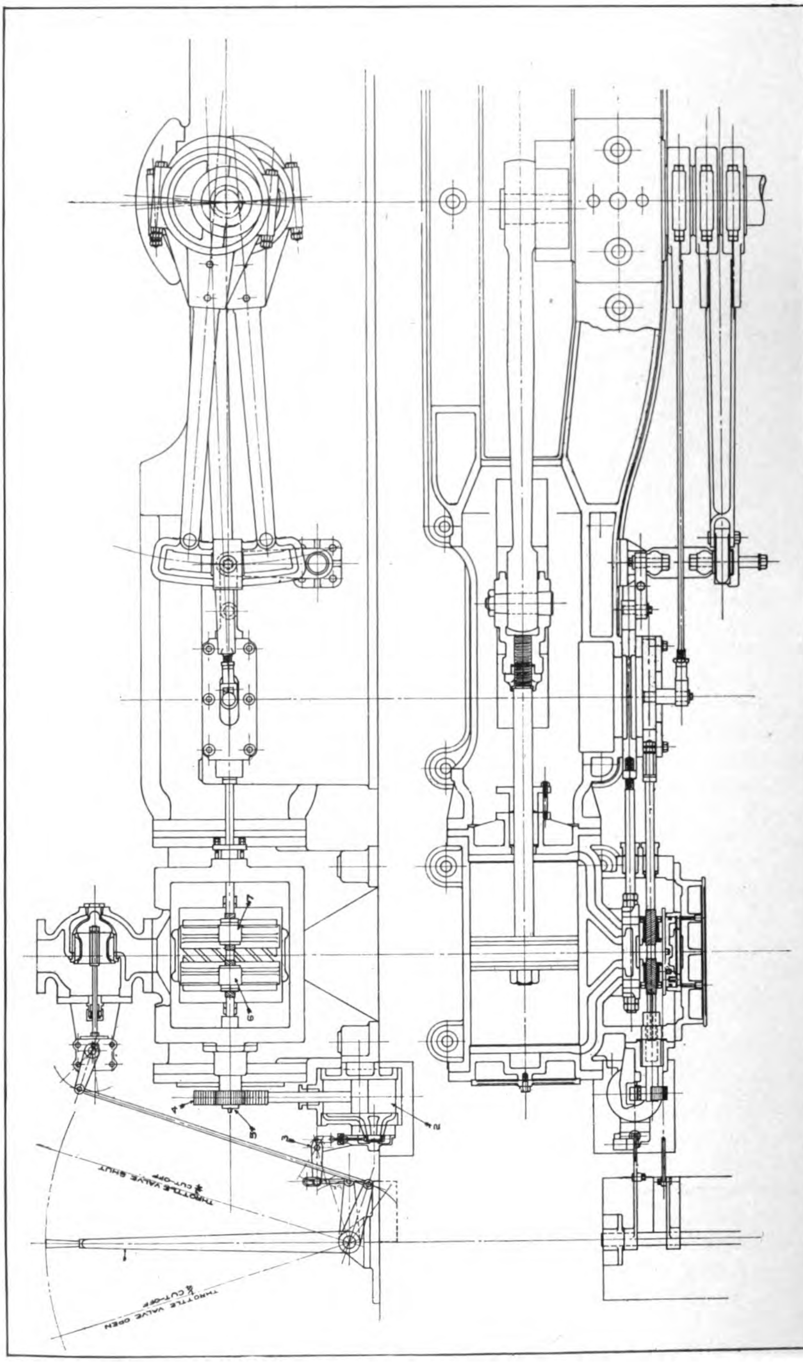
This plant consists of a drum, six feet in diameter, by six feet face, keyed to the shaft and driven through a gear and pinion by two 14x18-inch slide-valve reversing engines. The drum carries two 1¼-inch steel ropes, 850 feet long, and hoists in balance from two compartments of the shaft. It is capable of a net load of nearly six tons, which may be hoisted at from 720 to 860 feet per minute, depending on the engine speed, which varies from 150 to 180 revolutions per minute. Steam is furnished at 150 pounds pressure.

This hoist differs from other second motion slide valve plants in its steam economy, which is equivalent to that of a Corliss hoisting engine designed for the same service. This unusual efficiency is gained by automatic regulation of the point of cut-off of the slide-valves.

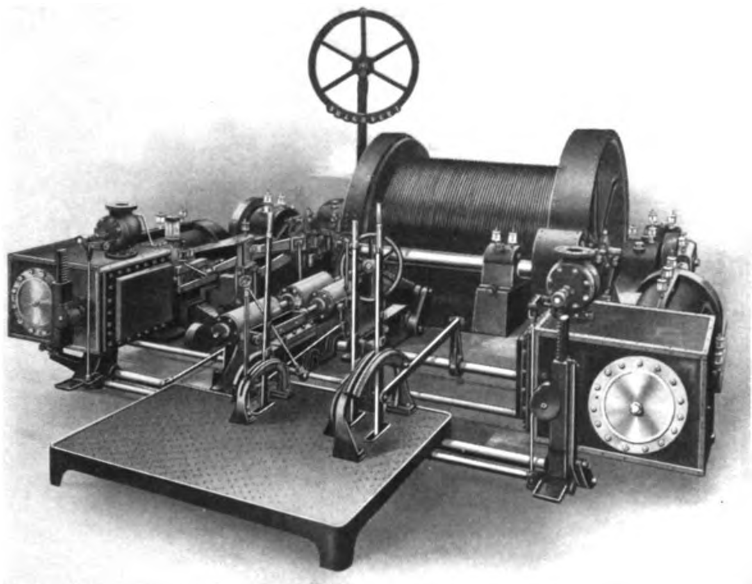
It may be asked: "Why is not the Meyer cut-off, with hand wheel adjustment, suitable for hoisting engines?" To adjust the cut-off by hand in this instance is out of the question, since it is necessary for the engines to take steam the full length of the stroke in starting the load; when the load is fully under way, the cut-off must be set in its shortest position. The cut-off must be lengthened again at the end of the hoist for the next load, and this operation repeated each trip. It is evident that no engineer has time to operate the screws between trips, nor would it be possible for him to set the cut-off at its most economical point each time, owing to variations in steam pressure and load.

The objection to using Corliss engines on geared plants, and thus gaining the desired economy, is that the Corliss valve gear and cut-off cannot be operated above a certain speed, so that the cylinders must be built with such a long stroke as to render the plant unduly expensive.

The device employed for doing this work automatically in these slide valve plants does not in any way limit the



Sullivan Automatic Slide Valve Hoist. Details of Engines and Valve Gear.



Sullivan Automatic Slide Valve Hoist built for the Cleveland Cliffs Iron Co. Rear view showing handling motion.

speed at which the engines may be run, thus permitting an engine of the most economical size and speed to be selected for a given duty. At the same time, it is possible to control the steam distribution as closely as in a Corliss engine, instead of wasting fuel by carrying steam the whole length of the stroke, as heretofore customary in engines of this pattern.

This invention, therefore, renders available a type of hoisting engine long sought by mine operators, one having moderate capacity and speed, with high steam efficiency, all obtainable at a price within ordinary means.

Credit for the new departure is due the engineers of the Sullivan Machinery Company, who have made a specialty of hoisting engine design for many years. An entirely new method is employed for controlling the cut-off of the slide valves. A double valve is used, as in the case of engines in which the steam distribution is controlled by hand adjustment. When starting the load, steam is admitted to the cylinders for the entire stroke. When the acceleration period is completed, the cut-off is automatically set at its shortest position in the following manner (see the drawing on page 336):

When the throttle-valve hand lever, No. 1, is thrown, the main throttles are opened by the first two or three inches of the movement, admitting steam for the entire stroke to start the load. As the lever is pulled back, it permits steam to enter cylinder No. 2, through the valve mechanism marked No. 3. The piston-rod of this cylinder ends in a vertical rack, No. 4, which engages a horizontal pinion, No. 5, located at the outer end of the spindle of the Meyer valve gear.

When the steam enters cylinder No. 2, by the movement of the throttle lever, the action of the rack and pinion automatically places the steam valves in the position of shortest cut-off. At the end of the trip the reversal of the lever, to

close the main throttles, admits steam to the opposite side of the piston in cylinder No. 2, and the cut-off is restored to its first position, to start the load from the bottom.

It will be noted that the automatic cut-off engine shown in the photographs is in a horizontal position. This enables the cut-off of both cylinders to be handled by one cylinder. The racks, in this instance, are operated by bell cranks.

It will be seen from the above description that the apparatus employed is very simple, and its action positive, reliable and not subject to derangement. It is entirely automatic, requiring no effort of action or attention on the part of the engineer, after the eccentrics have been set, to secure the most economical operation possible with the service factors of load and steam pressure which are prevalent. The slide valves are operated by separate eccentrics, with the usual link motion, the third eccentric shown on page 336, being for the cut-off. The range of the cut-off is from three-quarters to one-quarter at the latest setting, and from four-tenths to one-tenth at the earliest.

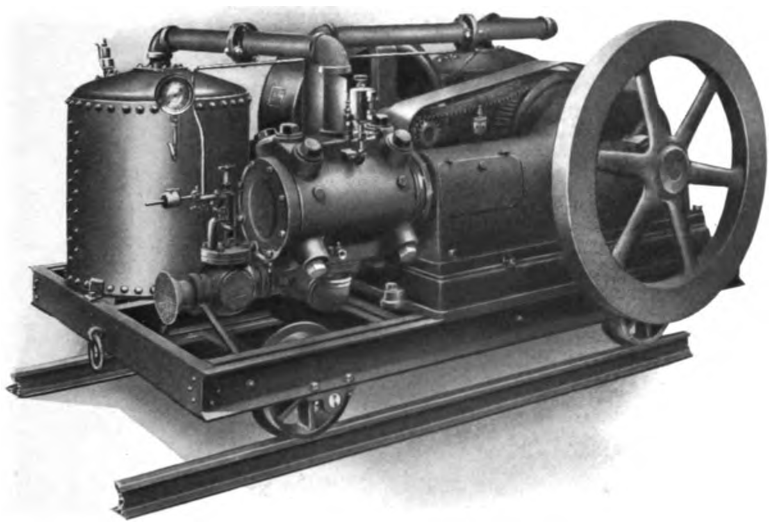
GENERAL FEATURES

The photographs on pages 335 and 337 show the general appearance of this hoisting plant, and of others of the same type. The drum is fitted with a heavy band brake, steam operated, with a wheel for setting the brake by hand at any point, for inspection or repairs, when the plant is not under steam. The gear and pinion are made of cast steel with cut teeth, the teeth being of such a shape that several of them are in mesh at once, thus rendering the action of the hoist smooth and quiet, even while lowering unbalanced.

The engines are mounted on heavy duty frames, the pillow block section and guide section being cast in one piece. The bottom, of these frames form enclosed boxes, to prevent oil from touching the foundations.

The hoists of this pattern are built in in several stock sizes, and all parts are interchangeable, enabling them to be made and sold at a smaller cost than is possible when each plant is a special proposition. It is expected that they will be employed extensively in mines where the requirements of depth, speed and load do not warrant the purchase of a first motion Corliss plant, but where economy of fuel is a factor.

The Cleveland Cliffs Iron Company has three other Sullivan Hoisting plants at its mines. One, at the Cliffs Shaft, consists of two 10-foot clutch-driven drums, operated by gearing from a 24x48 inch Corliss engine, with fly wheel brake. At the Stevenson Mine is a first motion plant, with a cross compound Corliss engine and two 12-foot drums, while the principal hoist at the Lake shaft, which the automatic slide valve machine above described serves as an auxiliary, consists of two 20x42 inch Corliss engines, driving directly two seven-foot clutch-operated drums.



Sullivan Motor-driven Compressor outfit on a mine truck.

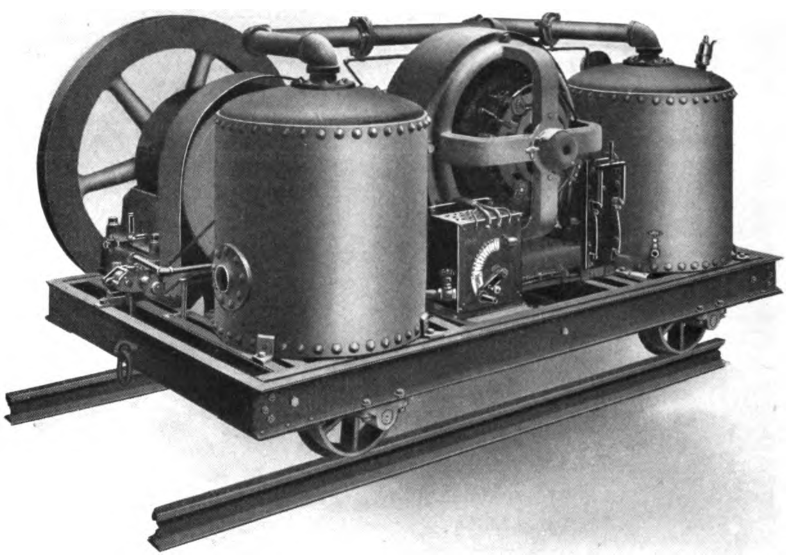
A PORTABLE ELECTRIC AIR COMPRESSOR

In mining and industrial service, there are many occasions when electric power is abundant, but in which work arises, which can be done to better advantage with compressed air. Again, when air power is on hand, it is sometimes inconvenient or impracticable to carry pipe lines to the work, whereas electric wires can readily be brought up to the working face or point of application. Among such instances are the operation of coal-pick machines in driving headings, the use of hammer drills or rock drills in remote and inaccessible workings, or any sort of temporary or occasional work in mines or construction undertakings, equipped with electric, but not compressed-air energy.

Another instance is that of pneumatic tools, — for example, in bridge or other steel construction, — when it is desired to convert electric into air power as cheaply as possible.

An air compressor for special service of the kind described, has recently been designed by the Sullivan Machinery Company, and is now in successful use. It is known as the class "WK" machine, and in the form shown in the accompanying cuts, is intended primarily for mining work. This outfit consists of a standard single stage compressor, driven by a silent chain from an electric motor, both motor and compressor being mounted on a truck, with wheels to fit the gauge of the mine track. The compressor is an adaptation of the Sullivan Class "WG-3" belt driven machine, the only alteration being the substitution of a sprocket or gear wheel for the chain drive, at one end of the crank shaft, in place of the two pulleys used with operation by belt. The crank-shaft, connection-rod, and other main working parts are contained in an iron housing, and are self-lubricated by the splash method.

The air cylinder is fitted with automatic poppet inlet and discharge valves, which are easily removable for inspection or cleaning. The air cylinder and heads are water-jacketed, the cooling water being



Sullivan class WK Compressor outfit, rear view, showing motor, receivers and circulation pump.

supplied by a pump, mounted on the truck, and taking its power by chain and sprocket from the compressor crank-shaft. This pump draws its water-supply from any convenient source, usually tanks or barrels on a standard mine car. The air inlet opening is covered with a screen to keep foreign substances from entering the air cylinder, and an unloading device is attached to this opening, arranged so as to shut off the supply of air, thus cutting down the amount of power used, whenever the air pressure in the receivers reaches the desired limit.

The motor is of the shunt wound continuous current pattern, and may be arranged for any desired voltage. It is fitted with a main line switch and fuse connection, mounted on a slate base, and a starting rheostat, with the necessary wiring and connections between the two.

One compressor of this type, which has been built and supplied for coal-mining service, has a 10 x 12-inch air cylinder, furnishing about 175 feet of free air per minute, at 150 R. P. M. The horse-power of the motor is 25, which easily maintains an air-pressure of 80 pounds in the receiver. This capacity is ample to operate a coal-pick machine or two small reciprocating rock drills, or several hammer drills or pneumatic tools.

The air-discharge from the compressor is delivered in series to two vertical receivers. Two receivers are employed, first, to keep down the height of the machine, and second, because a single horizontal receiver would not permit the necessary compactness of arrangement, and the proper relation between the positions of the compressor and motor.

The motor and compressor are bolted

firmly to a cast-iron sub-base, which in turn is bolted to a structural steel frame, mounted on the trucks.

In case mine or industrial track is not available in underground workings, or in a factory, or on construction work, wheels with wide tires may be substituted for those with flanges, and the outfit hauled from place to place on the floor or ground. For bridge construction or other railroad service, the frames may be bolted to a standard flat or gondola car.

DEEP DIAMOND DRILLING

In the March, 1909, issue of "Mine and Quarry," appeared a description of a diamond drill hole 3200 feet deep, bored near Bisbee, Ariz., on the ground of the Warren Development Co. At the time this hole was bored, it was the deepest core drill hole of which there was any record on the North American continent. Since that time, this record has been bettered by a hole 3265 feet deep, bored by Messrs. Cole & McDonald of Virginia, Minn., on iron ore land, in the vicinity of the American Mine, east of Republic, Michigan, on the Marquette Range. This work was done for Mr. Geo. J. Maas, and required six month's time. The drilling was done with a Sullivan Class "B" diamond drill, removing a 1⅛-inch core. The formation first penetrated was slate, reached about sixty feet from the surface. At a depth of sixteen hundred feet, quartzite was encountered. The supplies used in doing this work, included four sets of wire rope, three barrels of cylinder oil, two barrels of engine oil, and 125 tons of coal. 639 blank bits were set up to complete this work, making an average of about five feet drilled with each new bit.

BOOKS AND REPORTS

"Mine and Quarry" has received, from time to time, copies of the very thorough and complete reports issued by the Canadian Department of Mines, Mr. A. P. Low, deputy minister, and Mr. Eugene Haanel, Ph. D., director, and by the Department of Public Works of Canada. Those received since our last issue are as follows:

Report of Mines Branch, for nine months ending December 31, 1908 (96 pp.)

The Iron Ore Deposits of Nova Scotia, in two parts (Part I, 226 pp., 63 plates,) by J. E. Woodman, A. M., Sc. D., F. G. S. A., M. A. I. M. E.

The Chrome Iron Ore Deposits in the eastern townships of Quebec (141 pp., 10 plates), by Fritz Cirkel, M. E.

The Tungsten Ores of Canada (56 pp., 10 plates and bibliography), by T. L. Walker, M. A., Ph. D.

Investigation of an Electric Shaft Furnace (Domnarfvet, Sweden,) with plates, 40 pp.), by Eugene Haanel, Ph. D.

The Peat Bogs and Peat Industry of Canada, 1908-9. Bulletin No 1 (25 pp. with maps), by Erik Nystrom, M. E., etc.

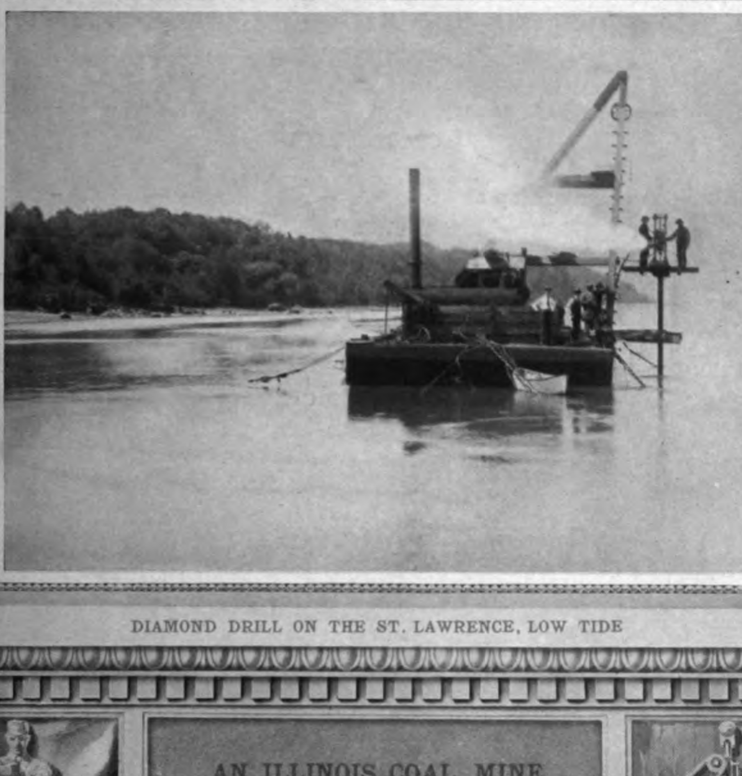
Report on the survey of the Proposed Georgian Bay Ship Canal, with plans and estimates of cost. (600 pp., fully illustrated with views of the proposed route, and 56 plates), by the board of engineers, E. D. Lafleur, A. St. Laurent, C. R. Coutlee, and S. J. Chapleau.

Space will not permit the extended mention which these reports deserve. They may be obtained from the departments above mentioned, at Ottawa.

R. R. DONNELLEY & SONS CO., PRINTERS.

MINE AND QVARRY

VOL. IV. No. 3 JANUARY, 1910



DIAMOND DRILL ON THE ST. LAWRENCE, LOW TIDE

AN ILLINOIS COAL MINE

BARRE GRANITE

THE VERMONT COPPER COMPANY

PVBLISHED BY THE SVLLIVAN MACHINERY CO. RAILWAY EXCHANGE BVILDING, CHICAGO.

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MINE AND QUARRY

Vol. IV, No. 3 JANUARY, 1910

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

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Readers are requested to notify MINE AND QUARRY of any correction or change in address.

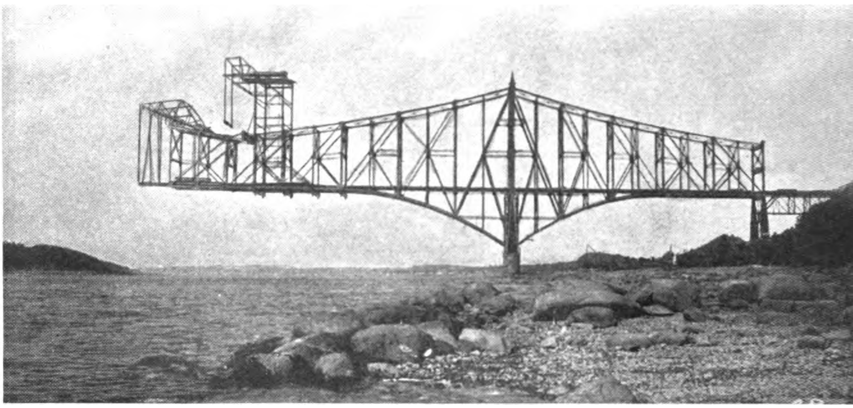
"The core's the thing," in diamond drilling, as an old advertising phrase has it. But after you have the core, what then? How shall one make the most of this valuable evidence? The interpretation of cores, and of the various signs which they bear, is in many cases a task requiring much ingenuity and technical ability. The article in this issue by a former state geologist of Michigan gives light on this phase of prospecting work. During the past five years, Professor Lane has examined and interpreted about 100,000 feet of diamond drill cores for copper companies in the Lake Superior district. In this work he has frequently had to solve mathematical problems of greater or less difficulty. His explanation of a typical problem will be of assistance to many engineers.

The coal-mine disaster at Cherry, Illinois, brings up for discussion the proper handling of the ventilating fan in case of accident.

Granted that the air current may be quickly and effectively reversed, when should this be done, and how shall the miners know that it is to be done? If the fan is exhausting, so that the hoisting shaft is down cast, and a fire starts near the latter, reversal would keep the flames back out of the workings and away from the men, who could then escape through the air shaft.

But each emergency is different from the last, and cannot be foretold. It would seem that every mine should be equipped with some alarm system by which the location and character of the danger could be immediately reported to the surface. And that if the fan is to be reversed, this fact should then be communicated to every part of the mine; and further, that, barring the possibility of giving instructions after the danger has arisen, a code of general rules for guidance of the miners should be adopted, so that they will know whether or not the fan is to be reversed, and what exit to seek under given conditions. These rules should be posted in conspicuous places, and their comprehension required of all workmen. Another important step is the use of concrete or brick linings for the shaft, shaft bottom, and main entries for some distance from the foot of the shaft. This is the general custom in European mines, and is valuable insurance against fire and explosions that wreck the ordinary timbered workings, and render them impassable.

MINE AND QUARRY will be glad to report discussions of these matters, and to hear of instances in which safety measures such as those suggested, are practiced.



View of first Quebec Bridge, taken shortly before the collapse

DIAMOND DRILLING IN THE ST. LAWRENCE RIVER, ON THE SITE OF THE QUEBEC BRIDGE

Written for "Mine and Quarry" by J. A. Wentz

Many readers will recall the failure of the Quebec bridge, across the St. Lawrence River, which occurred on the 29th of August, 1907. This bridge was of the cantilever type, with two shore piers and a river span 1800 feet long, 150 feet above the high water level of the river, which is 180 feet deep at this point. The bridge was being constructed for the Canadian Government, at a point about eight miles above the city. It was designed to carry two railroad tracks, two street railway tracks, two roadways, and two footways. It was to have been 67 feet wide and 400 feet in height to the peak of the main piers. When the river span, intended to be 900 feet from the center of the river to the north pier, had been constructed to a point 740 feet from the pier, some defect caused the collapse of the whole mass, carrying with it eighty men, of whom only four were rescued. The photograph on this page shows the bridge as constructed to the farthest point attained.

Work on the bridge was begun in 1902, so that five years' work was lost by this accident. Fresh plans have now been prepared by a Board of Engineers consisting of Messrs. Ralph Mojeski of Chicago, H. E. Vautelet of Montreal and Morris Fitzmaurice of London. The new bridge will cross the river at the same point as the old.

When the sites for the main piers were originally selected, the engineers were satisfied with the tests then made of the bottom. But there has been a marked advance in standards of accuracy in such matters in the last five years, and it was therefore decided to test the river bed and shore thoroughly with core drills to make sure that the piers were on a solid footing.

The Sullivan Machinery Company of Chicago was awarded the contract for this work, with diamond drills, and employed tv crews from May until November of this year. In all, nineteen holes were sunk,

and 2,000 feet of drilling performed. Some of the holes were on land, some at the shore line, in shallow water, and others on the river itself. The land borings were made in the usual manner, from the ground surface. For the shore borings, platforms 20 feet high were built, so that the drill was out of water at the highest tide levels. The river work proper was done from a scow.

This work presented features of unusual difficulty; first, on account of the rapid current; second, the depth of the water, which ranged from 30 to 48 feet; third, the danger of rough weather, and fourth, the tides, which cause a daily variation of from 12 to 18 feet in the height of the water level. In addition, the ground drilled was exceedingly troublesome, consisting of an irregular deposit of sand, gravel and boulders above the ledge or bed rock, and on the borders of the river, where the shore borings were made.

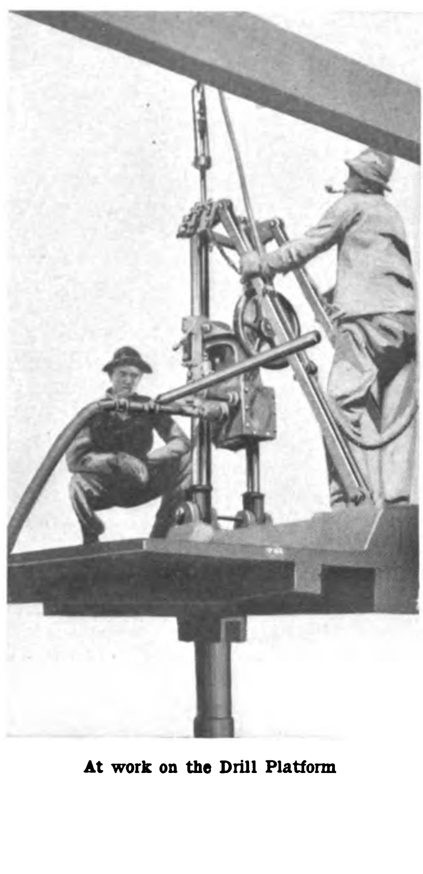
RIVER BORINGS

For the deep water holes, a Sullivan "B" drill engine and hoisting drum were mounted on a scow with boiler and tripod, as shown on the front cover. The boat was held in place by from four to six 500-pound anchors. The three-quarter-inch wire cables were taken up or paid out to keep the scow steady as the tide level changed. With the "B" engine and drum, six-inch standpipe was then driven down through the drift deposit of the river bottom by means of a drive block, or weight, sliding up and down on a drill rod, thus keeping it in line with the drive shoe on the end of the pipe. The six-inch pipe was followed by 4½ inch, and this by 2½ inch casing to the bed rock, which ranged from 50 to 130 feet below the bottom of the river.

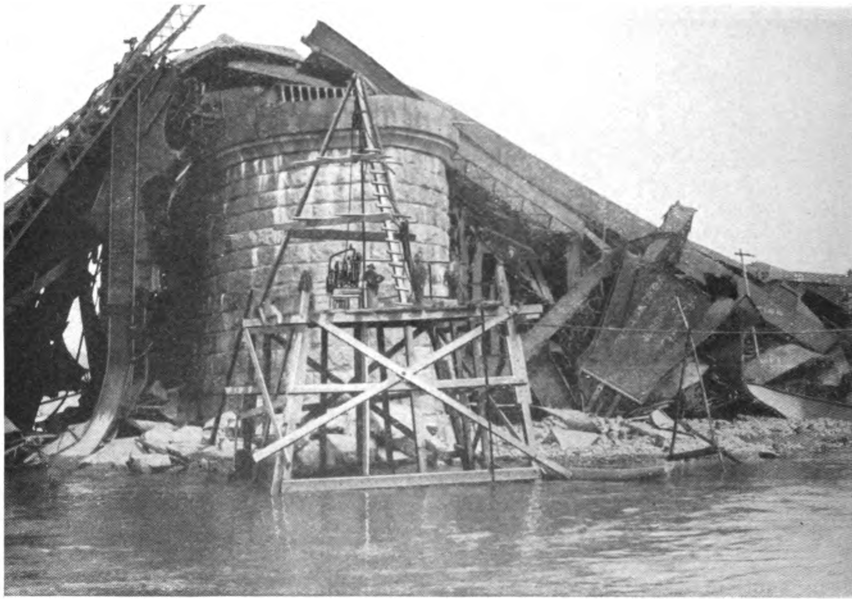
A large amount of blasting was required to sink the pipe to the bed rock through the boulders. This work was done in the usual manner, by lowering dynamite down the standpipe and withdrawing the pipe a few feet before the charge was fired.

While the standpipe was being driven, the variation in water level, due to tides, was taken care of by adding or removing the necessary lengths of pipe at the top of the line. After the drill had been set to bore into the ledge the length of the pipe remained fixed until the work was over, so that at low tide the drill was from 18 to 20 feet above water, as shown on page 344.

The actual drilling in rock was performed with a Sullivan "Badger" drill, mounted on a small platform on top of the standpipe, as shown in views on this page and the cover, and removed a 1⅛-inch core. The Government specifications required that the drill should penetrate the rock to a depth of fifteen feet, to make



At work on the Drill Platform

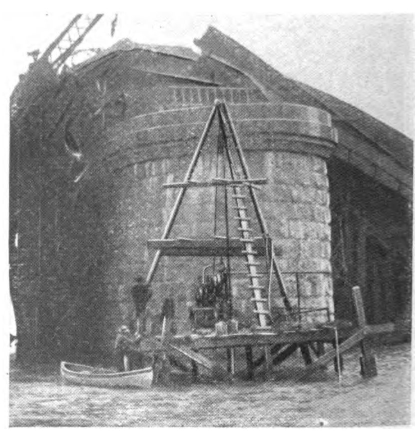


Drilling alongside pier of old bridge. This gives some idea of the wreckage; low tide

sure that the ledge and not a boulder had been reached. It was unnecessary to support the line of pipe through which the drilling was done by stays or guy rods, as the weight of the pipe itself and the firmness with which it was driven into the river bottom gave it sufficient rigidity.

INCIDENTS CONNECTED WITH THE WORK

The difficulties connected with this work were many, and rather out of the ordinary for a diamond-drilling scow. The water was very rough a large part of the time, owing to high winds. On one occasion all of the anchor lines parted, in spite of the fact that the time of two men was entirely given up to handling these lines. The scow went adrift, and for a time it seemed as though the whole outfit would go to the bottom. The crew were not used to sea voyages, and *mal de mer* added to their difficulties. By quick action on the part of J. V. Harrison, the superintendent, a tug was pressed into service, and the scow overtaken and towed to safety. The swell from ocean steamers bound to and from Montreal caused loss of time and annoyance, until an order was obtained from the Government officials requiring vessels to slow down while passing the scow.



Drilling alongside the pier; high tide

AN ILLINOIS COAL MINE

By M. C. Mitchell[1]

The Big Muddy Coal and Iron Company has been operating mines in Jackson and Williamson counties, in Illinois, for the past 35 years. Their No. 9 opening at Murphysboro, begun about three years ago, is an excellent example of approved methods in development and operation in this field.

GEOLOGY

This mine is one mile northeast of Murphysboro, on the east side of the Big Muddy River. The seam worked is known as the No. 2, but in reality is a combination of No. 1 and No. 2, which join at this point. The coal is about six feet thick, with a dip of one per cent. to the northeast, and is 114 feet below the surface at the shaft.

The product of the Big Muddy Coal and Iron Company is used widely all over the west, southwest and northwest for domestic purposes. An analysis shows:

Water	0.92
Volatile matter	35.05
Fixed Carbon	58.47
Ash	5.56
	100.00
Sulphur, separately	1.23.

SHAFT

Before sinking, the site for the hoisting shaft was determined by core drilling. The borings showed a bed of quicksand about 70 feet below the surface, and 14 feet thick. This difficulty was overcome by driving interlocking steel piling through the sand, inside the timbers, two feet into the slate below. Timbering was continued inside the steel piling to the coal without trouble.

MINING SYSTEM

The mine is being developed on the panel system. The bottom runs northwest and southeast, and extends 400 feet on each side of the hoisting shaft. It is 14 feet wide in the clear, to give room for double tracks, and is timbered every four feet with 12 x 12-inch timbers and lagged with 3 x 12-inch long-leaf yellow pine. The main bottom is parallelled by two side entries, one to the north and one to the south, used for motor haulage. These permit traffic between the two sides of the shaft, without interruption to hoisting from the bottom. Timber and other materials can be taken from the bottom to the side entries through the run-arounds without moving cars from the foot of the shaft.

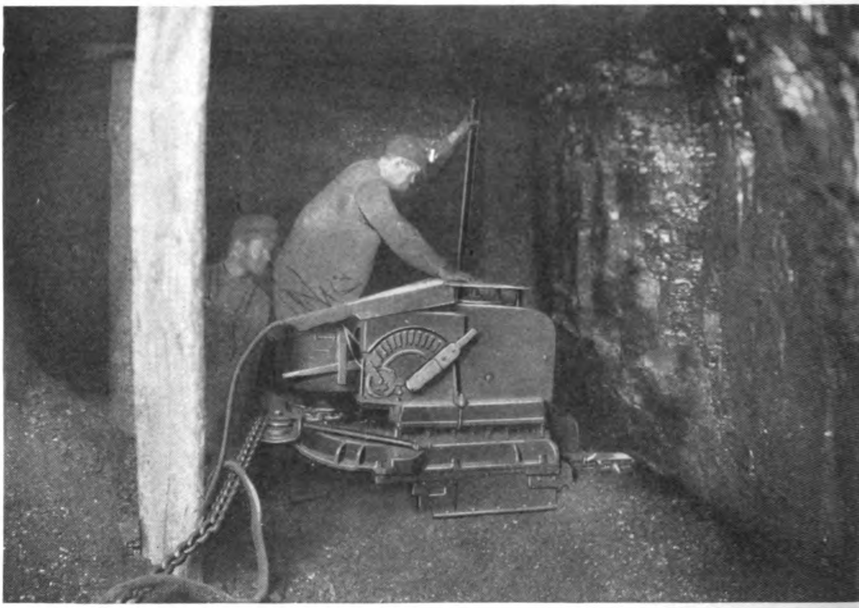
The main cross entries are also driven in triplicate, while the panel or stub entries, from which the rooms are opened, are driven on the double system. All entries, except the main bottom, are eight feet wide, and untimbered, with the coal arching over, allowing about 5½ feet above the rail. The panel entries are 500 feet apart. The rooms are therefore 250 feet deep, and are 18 to 20 feet wide and six feet high. There are 16 rooms on each panel, eight on each of the two entries. The panels are separated from each other and from the main entries by heavy protection pillars. The track is laid at the right-hand side of the room.

VENTILATION

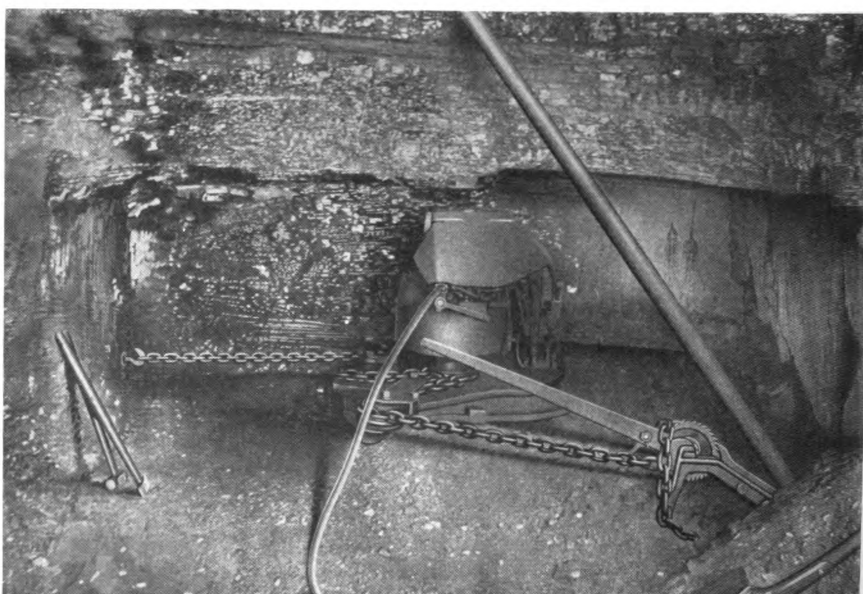
The air shaft is 300 feet northwest of the hoisting shaft, and may be used as upcast or downcast, as desired. The three-entry system provides adequate ventilation for the large area now under development. Air ordinarily enters the workings through the hoisting shaft, haulage road and traveling way, and returns through the third entry up the air shaft.

This mine contains no trap doors, except on the panel entries. These entries have each a separate split and are provided with overcasts of concrete and

[1] Missouri Trust Building, St. Louis Mo.



Sullivan "CE" Mining Machine crossing the face of a room



Sullivan Mining Machine driving an entry

steel. All brattices in cross cuts are of concrete, except those on the panels, which are wood. After the panels are worked out, the panel entries are shut off from the main entries with concrete dams. There is no connection between the different panels, so that in case of fire or flooding a panel may be isolated from the rest of the mine. This provision also enables fresh air to be carried directly to the working faces. The hoisting and air shafts each contain separate compartments equipped with stairways. Doors at each end of the bottom make each shaft independent of the other. A fireproof door connects the north entry, running parallel with the bottom, with the man-way to the air shaft. This manway is not used for ventilation. It is fitted with doors opening toward the shaft. The high speed steel ventilating fan passes 100,000 cubic feet of air per minute against a water gauge pressure of 2 inches. The steel and concrete fan house is set 25 feet back from the shaft, and is connected with it by a concrete tunnel. The air shaft is made air tight and water proof by a double layer of two-inch plank.

ALL COAL UNDERCUT BY MACHINE

All coal in this mine is undercut before being shot by electric chain mining machines of the Sullivan "continuous cutter" pattern. These machines make a cut 6½ feet deep by 5¾ inches high. Nine of these machines are at present in use, produing 1300 tons per eight-hour day. The mine was developed with these machines, and three of them are still engaged on narrow work, the remainder cutting the rooms. The method of development is as follows:

NARROW WORK

The machines drive the main, cross and panel entries, turning off and widening the rooms on the panel; when enough rooms are opened to keep a machine busy, a separate machine is assigned to this section of the mine, taking care of all the rooms. The first machine moves forward to repeat the process, and thus development has been very rapid. This plan permits larger tonnage to be secured from rooms, and a greater length of entry to be driven, than would be the case if production were started in each room as soon as opened, since there is no time lost by machine men in waiting for drivers, and vice versa.

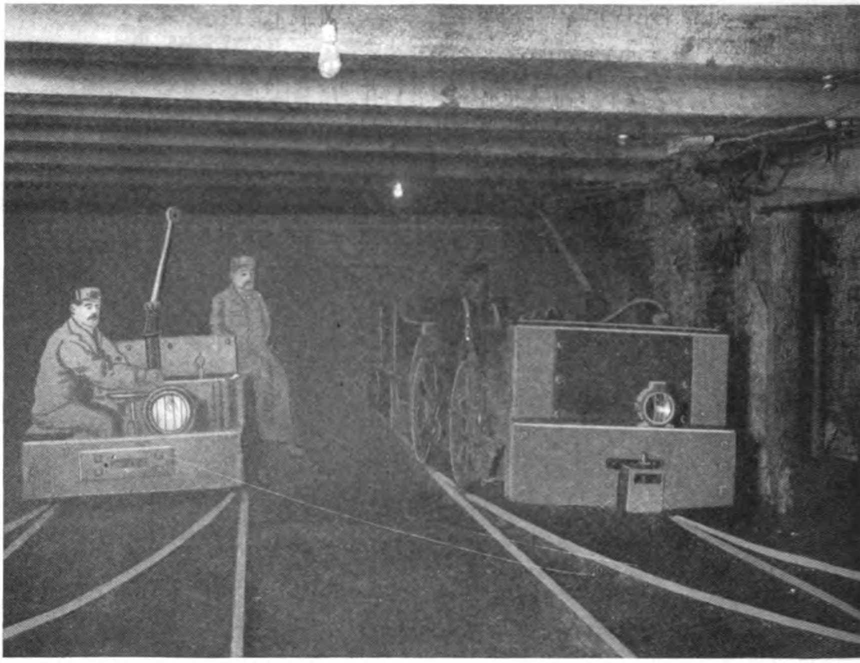
Page 346 shows one of the Sullivan machines driving an entry. These machines have shown themselves well adapted to narrow work, on account of their compactness, speed, and the ease with which they are handled under their own power.

An average day's cutting is from 8 to 12 8-foot entries. Each entry in the section being developed is usually cut twice a day, giving an advance of 12 feet per entry per day. Each machine on narrow work averages 80 tons per day. In this mine a new runner has cut seven entries in less than five hours, and 13 entries have been cut in 7½ hours, including two moves of over 1000 feet each. In one entry the machine occupied 13 minutes in unloading, cutting and reloading.

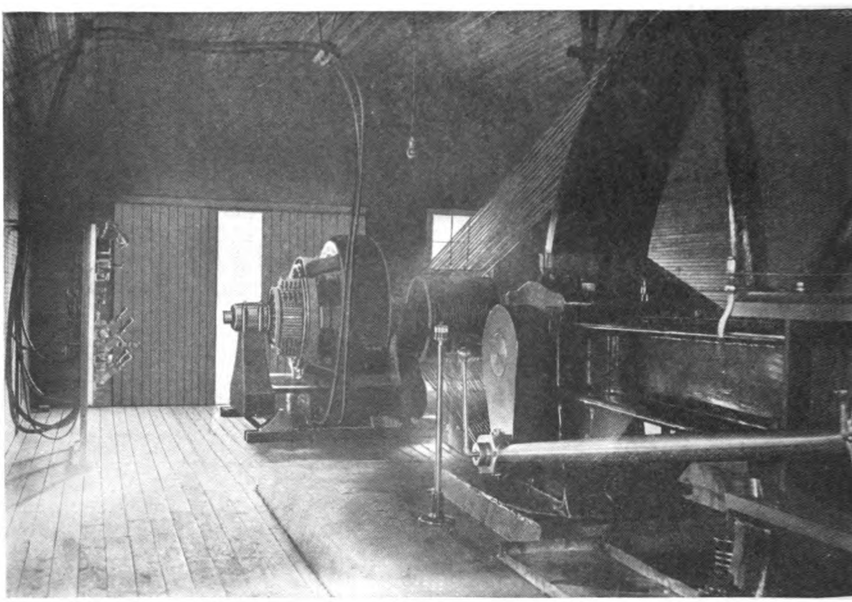
One of the advantages if this machine in entries is its ability to turn off cross cuts or other narrow places at right angles in these cramped quarters. This obviates widening the entries at these points, or increasing yardage by angle cross cuts, and leaves a minimum amount of roof to be propped.

ROOM WORK

In cutting the rooms the compactness of the "continuous" cutting machines is again valuable, on account of the proximity of the supports to the face. After the machine has been sumped at the right rib, the pan, or rear half of the frame, is detached; the jacks, with the feed chain between them, set at opposite sides of the room, and the machine mines the whole face at one operation, without moving the props. (See cut on page 346).



Electric Locomotives in the main bottom entry



The Electric Power Plant

The machine then pulls itself back to the track, loads itself on the truck, and proceeds under its own power to the next room. In cutting these 18 and 20-foot rooms 175 to 180 tons per machine is an average day's work (single shift).

The machine is arranged to cut about three inches above the floor of the room. This leaves a very smooth surface from which to shovel the coal, and prevents the miner from loading fire clay. After loading out all the coal the bottom is taken up and loaded in large pieces, and the room squared up ready for recutting. The cuttings left by these machines range in size from slack to medium-size nut. They are classed as screenings in the market, and make an excellent steam fuel.

In shooting the entries, three holes are employed, with a pound and one-half of powder in the center, and about three-fourths of a pound in each rib hole. In the rooms the three holes are each loaded with a one and three-quarter pound charge. The blasting is all done at the end of the working shift.

HANDLING THE COAL

The coal is loaded into two-ton cars, with 42-inch track gauge. The cars are hauled by mules to the inside partings, where they are made up in trips and hauled by electric locomotives to the shaft bottom. The coal is all caged from the west side of the shaft, and the empties run by gravity about 400 feet to the east, where they are picked up by the electric locomotives and pulled back to the inside partings. The coal is hoisted in self-dumping cages by an 18 x 36-inch first motion steam hoist, having a single conical drum ranging from five to seven feet in diameter, and using 1⅛-inch rope. It is then dumped into a hopper, weighed, and passed over a shaking screen, which separates it into market sizes. There are four tracks below the tipple, each with a 78-foot scale, controlled from the shipping clerk's office by independent beams. This arrangement facilitates weighing of empties, loading with any desired grade of coal, and re-weighing, before shipment. There is also a box car loader in connection with the tipple.

ELECTRICAL EQUIPMENT

Direct electric current at 250 volts for the mining machines, the two electric locomotives, lights, etc., is furnished by a 225 k. w. generator, operated by rope drive, as shown on page 348, from a Corliss engine. The power house is 50 feet away from the boiler plant. Power is taken underground in separate circuits, each operated independently from bus bars at the switch board, with a switch and circuit breaker on each line. The cables are located in the man-way of the hoisting shaft, in separate lead conduits. Two of the circuits are used for haulage, and two for the mining machines, each half of the mine being independent of the other. The electric lights are on a fifth separate circuit and burn continuously while the mine is in operation, without danger of being affected by trouble on the machine or locomotive lines.

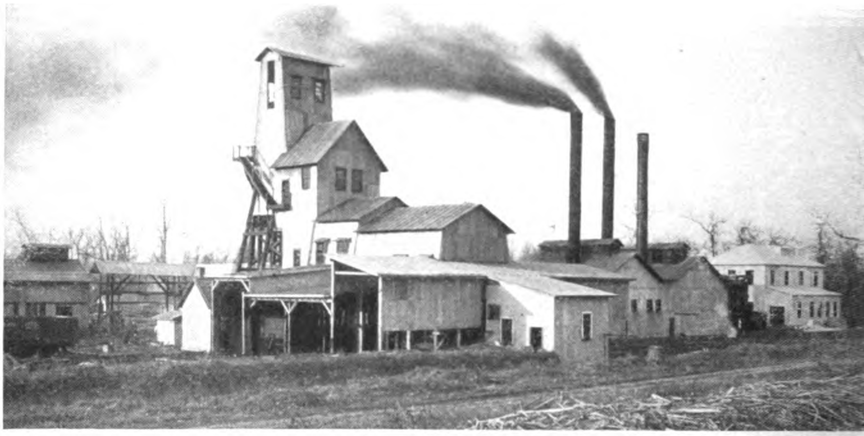
For getting quickly from place to place underground, the mine manager and electrician use electric speeders. The former has a three wheel velocipede and the electrician a light car with four wheels, which enables him to carry small supplies or repairs with him.

SIGNALS

An electric signal station is provided at each inside parting for each double set of panels, to control the movements of the drivers in the panels and headings. The switch tender operates all the switches from this station by means of rods running along the side of the track to the switch stands. When the track is clear to the parting the driver is given a white light, and comes through without stopping, but if the track is occupied a red light holds the trip until the way is again clear.

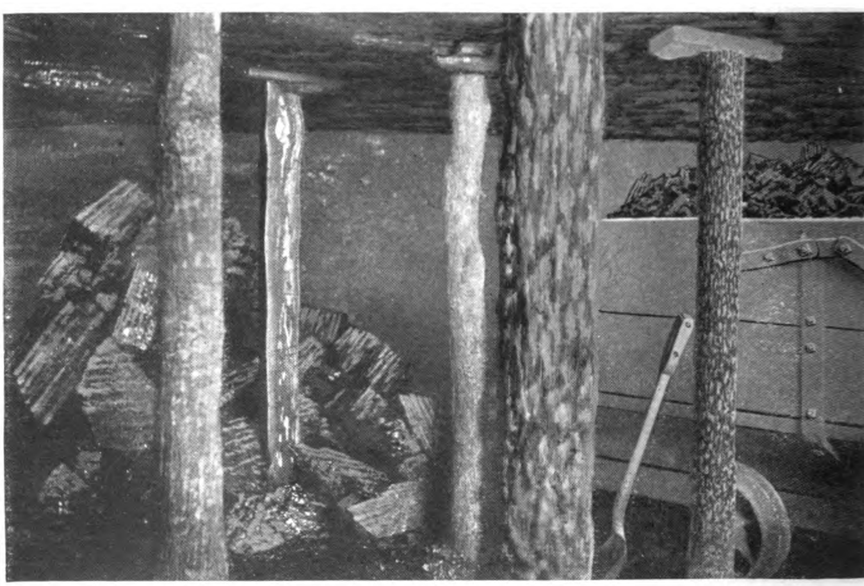
SURFACE PLANT

In addition to the fan, hoist, tipple and power station described above, the surface plant includes boilers of 900 H. P., a warehouse, machine shop, barns, powder and oil houses.



Surface Plant of Big Muddy Coal and Iron Company, No. 9 Mine

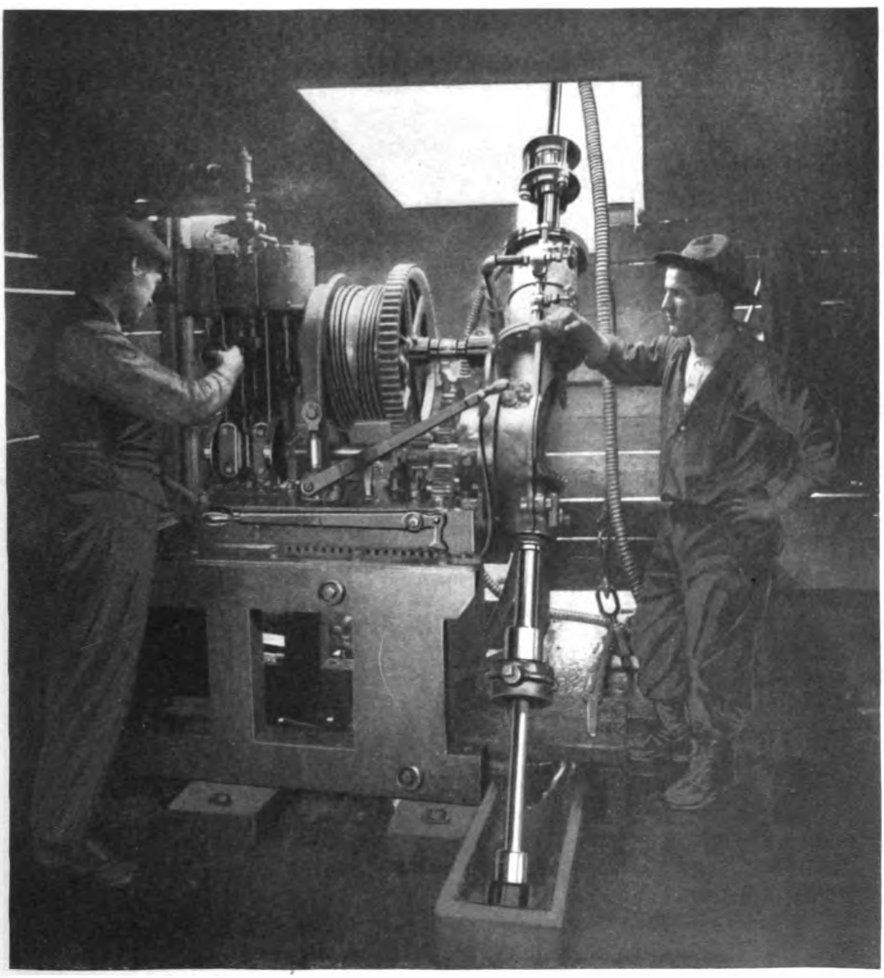
Coal for the boilers is carried from the tipple to the boiler house by a chain conveyor, capable of handling 50 tons per hour.



Loading out coal from an undercut room

The Briquette Coal Co. of New York is installing a briquetting plant for making the small coal into briquettes. This plant is located just north of the boiler house, and will be in operation shortly.

The writer is indebted to Mr. Hiram Willson, superintendent of the Company at Murphysboro, for the above data, and to Mr. Jesse Mitchell, Mine Manager, and Frank McFarlin, Master Mechanic, for assistance in securing the photographs used in this article. The general offices of the company are in the Wainwright Building at St. Louis, whence all business is carried on for the mines in Jackson and Williamson counties. Mr. O. L. Garrison is the president of the Company.



Class "H" Sullivan Diamond Drill, Vermont Copper Company

THE VERMONT COPPER COMPANY[1]

A NEW ENGLAND "ANTIGUA"

The property of the Vermont Copper Company, in Orange County, Vermont, belongs to the older generation of mines in the United States. As the Vermont Copperas Company, it was a producer of copperas, as early as 1790. It was not until about 1837 that the ore began to be treated for the copper it contains (about 2.5 per cent). Until the development of the Lake Superior district, the mines of this county were the largest shippers of copper in the country. The output of the mine was hauled to Boston by wagon. Surveys for a railroad have since been made in all feasible directions, and the state has issued a charter for such a road, but it has not yet been built. Transportation is still by wagon, to the Boston and Maine station of Pompanoosuc, 12 miles northwest. The village of South Strafford, two miles to the west, is the nearest town.

ORE

The ore occurs in lenses in what appears to be a fissure vein. It consists largely of pyrrhotite in which is a small amount of chalcopyrite, finely disseminated through the ore body, so that in previous concentration methods a large percentage was lost. The wall rock, both hanging and foot, is a micaceous schist. The strike of the vein is approximately north, 20 degrees east with a dip varying from 70 to 50 degrees as depth is gained.

DEVELOPMENT

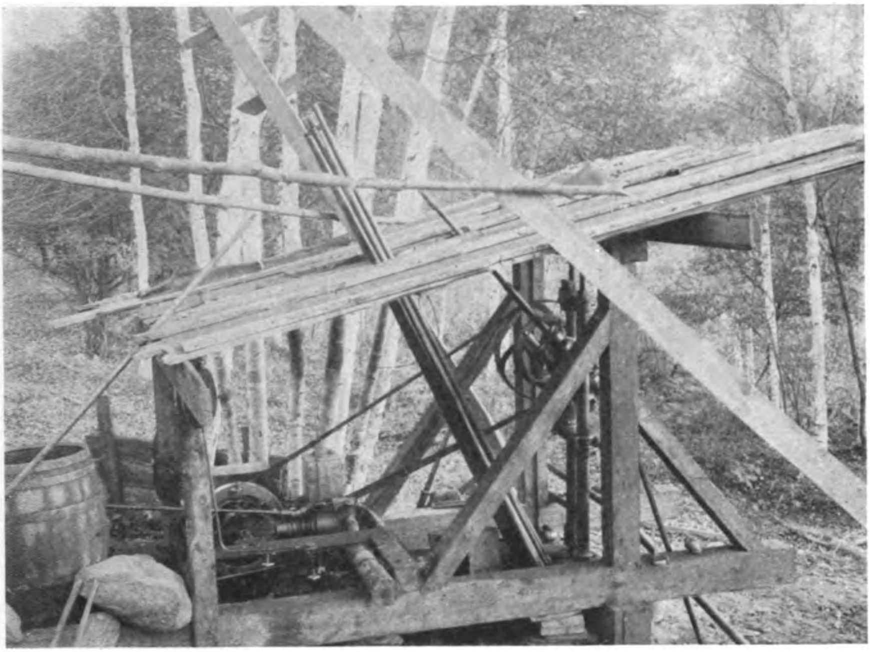
The ore body is 10 to 25 feet thick and the management estimates that about 400,000 tons of ore are now developed. The old work consisted of a large open pit, in which hand labor was employed. The great extent of the surface croppings finally led to underground exploration and development, and to machinery. The mine extends several thousand feet in a north and south direction. A haulage tunnel, 1,500 feet long, runs into the mountain from the power house, and taps the vein at a depth of about 400 feet. The vein has been opened up by a drift some 1,800 feet in length, and above this level a large amount of ore has been removed. An incline 500 feet long, at the north end of the mine, is in ore 200 feet below the main level.

EXPLORATION

Three Sullivan "H," hydraulic-feed, diamond drills, are kept going day and night for the purpose of proving up a long extension of the vein which has been followed. In order to prove thickness the holes are bored on a slant to cut across the vein. One of these drills is shown on page 351. The cuttings in the vein and the core are used for estimating the quality of the ore. These drills are all operating from the surface, and are run by compressed air. To make up transmission losses, the air is reheated by building a light wood fire for a length of five to ten feet under the inlet pipe supplying each drill. The amount of air consumed in one of these diamond drills varies, but to give an idea, it may be noted that the drop in pressure from 70 pounds, while running two of the drills together on a 1½-inch supply pipe, was 13 pounds.

A Sullivan "E" screw-feed diamond drill mounted on a frame for surface prospecting, is also in use. A gasoline engine mounted on the same frame drives the machine by belt. The water, thus far, has been supplied by a hand pump. The rods are hoisted with the engine and pulley blocks, the rope passing around the "capstan" on the fly-wheel of this machine, with about one and a half turns. The photograph on page 353 shows the general arrangement. All these pros-

[1] Prepared from notes furnished by the general superintendent of the Company.



Sullivan "E" Diamond Drill, driven by a gasoline engine

pecting drills use either "E" ($\frac{15}{16}$-inch) or "A" ($1\frac{1}{8}$-inch) bits. These machines, drilling in the schist, make about 15 feet on an average per ten-hour day; out of the core probably ten per cent contains quartz, sometimes solid for three or four feet. The distance covered in this prospecting will approach two miles, while the depth of holes is from 300 to 650 feet. The vein is remarkably steady, but there are pinches in it, as occurs in many ore bodies. The grade of ore on the whole is low, but some of the holes, as well as stopes in the mine, run high in copper (eight per cent).

GROUND BREAKING

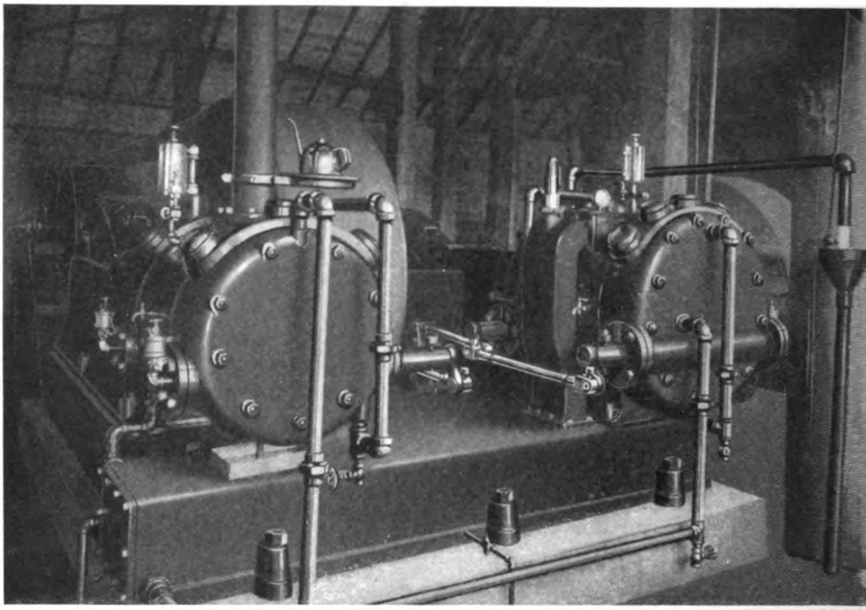
The general method of mining employed is underhand stoping. For this purpose, Sullivan "UC" $2\frac{3}{4}$-inch air drills are used, mounted ordinarily on tripods, although some work is done from stoping bars. Steam drills of the same size and type have also been used for quarry or open cut work. The mining drills put in 40 feet of hole, on the average, in ten hours in this rock.

HAULAGE

The haulage roads in the mine are laid with 28-inch gauge track, and 30-pound rail. The five-ton cars are hauled by an electric trolley locomotive of 56 horsepower (seven-ton) capacity. The ore is handled in the stopes through chutes, and when necessary is hauled to the chutes in small cars. The chutes deliver to stalls above the main level, whence the cars are filled by gates at one side. The 500-foot incline is served by a small hoisting engine and automatic dumping skip. The skip dumps into a bin from which the cars are loaded.

COMPRESSED AIR

The convenience of air has led the management to use it wherever possible.



Sullivan "WJ" Belt-driven Air Compressor of the Vermont Copper Company

Power for the rock drills, winze hoist and the three "H" diamond core drills, pumps, etc., is supplied by a 14-drill Sullivan compressor, of the "WJ" duplex, two-stage, power-driven type. This machine is equipped with water-jacketed cylinders and heads, a large copper tube intercooler, semi-rotary inlet and poppet outlet valves. A cut-off regulator or unloading valve on the air intake pipe shuts off the air supply when the receiver pressure exceeds the 85-pound limit, thus enabling the compressor to run unloaded when the full amount of air is not required. This regulator and the combined bath and gravity oiling system employed for the main working parts, render the compressor practically automatic. The machine is driven by a 150 horse-power alternating current motor. For the sake of compactness, the motor is placed beside the compressor. An 18-inch belt drives a jack shaft, which transmits the power to the 30-inch main belt, running with the upper side in tension.

A 5-inch main carries the air through the 1,500-foot adit to the main level, where it branches and is reduced. The supply pipes for the diamond drills are 4,000 feet long. The entire system can be pumped up to 85 pounds pressure in four minutes, and tests have been made of the compressor by an accurate measurement of the volume shut off in these pipes and in the receiver and by checking the number of revolutions required to pump this volume to 85 pounds, due allowance being made for temperature.

POWER PLANT

Steam power was used at first, to run the compressors and blowers. A few years ago, a concrete dam 400 feet long was built on the White River, ten miles distant. The power house contains two 400 horse-power turbines, direct-connected to generators with rotating fields. The three-phase, 6,600-volt alternating current is transmitted by steel cables across the river and then by wires to the

mine, where it is stepped down to 550 volts.

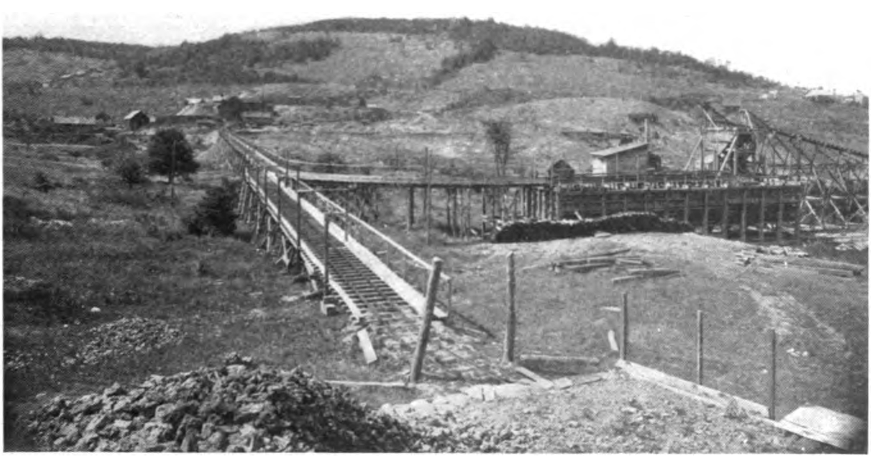
The central plant at the mine includes a well-equipped machine and repair shop.

SMELTING PLANT

The ultimate object of this operation is the production of copper matte. The metallurgical process will consist in smelting in a water-jacketed furnace, allowing a deep ore column and also a heavy blast from the Root blower. This furnace is water-jacketed and about 16 feet by 44 inches between tuyères. At first this furnace was enclosed in what was supposed to be a slow-burning timber building, but last February a disastrous fire, due to a breakout of low grade matte from an enormous settler, caused the destruction of the plant. It has therefore been rebuilt out of steel and corrugated iron. The large settler has been replaced with a more reasonable one, the blower has been repaired and the furnace divided in half its original size. This is for the purpose of better control and the determining exactly of the practice that can be successful on a large scale. The copper matte formerly was produced by an old jacketed furnace, but it was deemed unwise to use this with its wooden surroundings, because the height of the furnace would probably not have been suitable in all cases arising in the semi-pyritic smelting contemplated. The new furnace can at any time be rearranged so as to give the full capacity, or three-quarters capacity. Proper spouts also have been provided and it is expected that there will be no trouble from this or from lack of blower capacity.

ORE HANDLING

The ore, hauled from the mine by electric locomotive, as described above, is received in bins above the crusher in the mill, while any waste goes to a dump at the side of the mill. The ore is crushed to four inches, elevated by a belt at an angle of 130 degrees, recrushed and sampled in an automatic sampler of the Vezin type, but built according to original plans. The bins below the sampler furnish the



General view of the Vermont Copper Company's Workings. Furnace bins at right, mill in background

ore to a larry that travels over the bins above the furnace. These hold about 2,500 tons of ore, also coke, silica, and matte. An automatic weighing charge car run by trolley, with four beams to weigh different ingredients, then carries the ore into the furnace, from which the slag is discharged by three-tons lag pots on a circular track, and the matter is broken by hand, loaded on wagons and hauled to the railroad for shipment to the refining centers.

The smelting plant has been out of commission for several weeks, on account of a gas explosion which recently occurred in the long brick flue between the blast furnace and the chimney on the hillside, blowing out a section of about 100 feet. Fortunately no one was hurt. Everything was running smoothly when the explosion occurred.

UTILIZATION OF FIRE DAMP AS FUEL AT SARREBRÜCK[1]

[Note — The employment of mine gas for firing boilers is unique, so far as known to the editors, and at a coal mine bespeaks an economy which American managers might emulate with profit. The inference of the author, that one of nature's gas factories has been tapped, and not a mere reservoir, is a valuable suggestion for the student of mining problems.—Editor.]

An occurrence, which may furnish some indications as to the location of fire damp in coal deposits, took place about eighteen months ago at the Frankenholz Mines, located at the northeastern end of the Sarrebrück Basin. The Frankenholz Mining Company has authorized me to publish a few data on this subject. I am pleased to express here my thanks to the managing directors.

GEOLOGY

The coal-bearing measures of the property worked by the Frankenholz Mining Company are divided into two portions by an important fault, running approximately from northeast to southwest, with a strong dip towards the north. The productive portion of the coal deposit is north of this fault, and above its plane. South of the fault and below it the ground is very much shaken and pushed upwards. In a long exploratory drift from pit No. 1 towards the southeast, gray and red gritty strata have been found, containing fossils which, according to the opinion of Mr. Zeiller, place these strata in the Autunian period. Messrs. Bergeron and Weiss have assumed from this condition of the strata that the Autunian sandstones form an anticline upon which the coal measures of Sarrebrück rest, and that the Sarrebrück Basin, in its entire extent, is merely a heavy surface deposit, whose southern margin at Frankenholz should correspond to the crest of the Autunian sandstone anticline. Whatever may be the case, the principal fault to which I have just alluded is accompanied in the region northeast of pits No. 1 and 2 by numerous very regular, but unimportant small fractures, affecting the coal measures. In the region situated west of these pits, however, it appears that another fault is encountered, grafted on the first one. The plane of this is nearer the vertical and runs east and west. This other fault is, properly speaking, a coördination of small faults of the same direction and dip. These fractures have limited, in the upper levels, the working of the coal seams to the south, because of the proximity of the southern borders of the property. As the workings became deeper, the dip of the faults toward the north gradually reduced the workable area between the faults and the property line. It therefore became of importance to penetrate

[1] A paper read by Henry Joly, Doctor of Science, Professor of Geology of the Lorraine District of the School of Science, at a meeting of the Société de l'Est, translated by A. de Gennes.

these small faults so as to learn whether the coal measures below contained workable seams.

A DIAMOND DRILL HOLE

With the intention of prospecting the deposits, a horizontal bore hole 4 centimeters in diameter was put in by means of a Sullivan diamond drill. At the point where the bore hole had penetrated the fault, at a depth of 60 meters, and was entering the coal-bearing sandstone, the rods were suddenly thrust back out of the hole by a violent explosion of fire damp. After waiting a few days, it was found that the flow of gas did not decrease, and that it was impossible to block up the bore hole, on account of the heavy pressure, which was about 15 kilograms per square centimeter. Steel pipe was therefore forced into the hole, and the gas thus led directly into the pit or main workings, by the air-return passageway. About a month later, a conduit was made to lead the gas up to the surface.

USE AS FUEL

Still later, five or six months after the fire damp had been discovered, the mine authorities thought of using the gas as fuel, and one of the boilers in the power plant was fired by this means. Burners of the Bunsen type were placed in the fire box, fed by steel piping of 15 centimeters diameter. A short time after this, the flow from the bore hole was decreased by reason of fragments of rock, which fell from its sides, and partially stopped it up. It was then decided to bore a second hole four centimeters in diameter, about 35 feet distant from the first, with a view to exhausting the deposit of fire damp, and at the same time reguating the flow to the boilers. Every necessary step was taken for the convenient and immediate storage of the gas, and while this was being done, new burners were placed under another boiler. The second hole gave approximately the same flow, and the same pressure as the first. The piping carries the gas into a steel tank, in which the fragments of rock and water entrained by the gas are deposited. This tank contains an apparatus for measuring the pressure, and from it the gas is led in 15 centimeter steel pipes to the boilers. The results of the storage of this fire damp are as follows:

CONCLUSIONS

For the last four or five months, the flow of gas from the two bore holes has been maintained at a constant point, amounting to about twelve cubic meters per minute. It is used for firing boilers, and the quantity of water thus vaporized in twenty-four hours by means of fire damp only is 100 cubic meters. From the above, it is hardly conceivable that the fire damp was enclosed in a cavity in the rock, and that it was in existence before being tapped. We must assume that the gas was formed spontaneously, upon the introduction of the lower pressure, from unstable constituents, contained in the fissured coal schists. It should also be remarked that fissures or cavities in the ground may enclose a certain amount of fire damp and thus equalize the outflow of gas when one of these fissures is opened by a small orifice, but it is evident that these fissures which contain the fire damp are not very extensive, and that the fire damp does not travel or proceed from any considerable distance; for the drift which penetrated the upper fault at a level below that of the bore hole has encountered no fire damp, and according to the surveys of the mine, it appears that at a horizontal distance of sixty meters, the bore hole cannot be very far from this fault, if it does not actually reach it. Thus, while the origin and mode of formation of fire damp remain unknown, these facts will perhaps make a small contribution to the study of these causes, and it is for this reason that I have considered it of value to publish them here.

A typical "Boulder" Quarry

THE GRANITE INDUSTRY OF BARRE, VERMONT

By George H. Gilman [1]

To those interested in rock products, "Barre" means "Granite," for this enterprising city has the distinction of leading the world in its output of that stone, amounting in the year ending in June, 1909, to above 250,000 tons.

Barre lies in a beautiful valley, in Washington County, 71 miles north of White River Junction, in central Vermont. Shipping facilities are provided by the Montpelier and Wells River Railroad, which connects with the Boston and Maine at Wells River, 40 miles to the east; and by the Central Vermont, via Montpelier Junction, seven miles northwest of the city.

HISTORY

The quarrying of granite at Barre dates back for nearly a century, when mill stones were cut from a hillside now known as Millston Hill, and where, at the present time, the majority of the quarries are situated. Many of them were opened up long before the machinery of to-day was thought of, and there still remains evidence of the early methods then employed, when the stone was split by wooden plugs driven into a slot channeled several inches deep, and expanded by water.

Although it was known so early that the Barre hills contained granite of superior quality, the distance from markets was long a hindrance to development. The population in 1840 numbered 2126, in 1860, 1839, and in 1880, 2060. But in the decade from 1870 to 1880 the foundations of the stone industry had been laid, and with the coming of the Montpelier and Wells River Railroad, the town grew to 6800 in 1890. Since then the growth of Barre has been steady and substantial, fostered by added railroad service, the development of machinery, and the increasing reputation of it sproducts. The population is now over 13,000.

[1] Claremont, N. H.

A typical "Sheet" Quarry

THE QUARRIES

There are to-day about 55 separate quarry workings, owned by 22 different concerns, and scattered over an area of about two square miles. These quarries may be divided into two classes: "sheet" quarries, in which, as implied, the stone lies in sheets or layers, approximately horizontal, and increasing in thickness as greater depths are reached; and "boulder" quarries, in which the joints are irregular and often crowded together. The photograph on this page is a good example of a sheet quarry, and that on page 358 shows part of a boulder quarry.

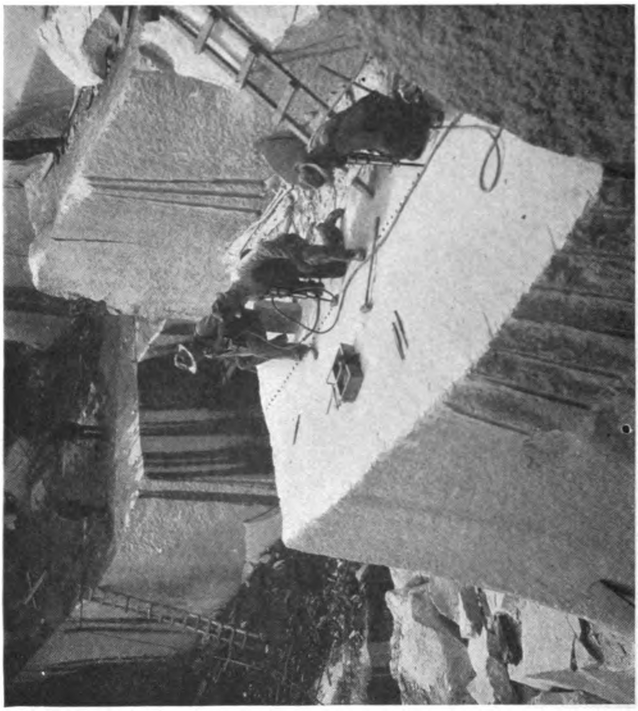
The granite quarried throughout the territory varies little in the proportion of the constituent minerals, namely feldspar, quartz, and mica; and upon the amount of black mica depends primarily the grades of dark, medium and light stock known to the trade. In color it is gray, or bluish gray, and is very free from imperfections, such as streaks or discoloration. This fact permits the quarrying of uniform stone of any size up to the limit of transportation. Barre granite is remarkable for its beauty in the rough and in polished forms. Its ability to resist weathering and to continue to look clean and bright after exposure is famous, as well as its wonderful adaptability to tool treatment.

At the extreme north of the territory covered by the quarries, the stone is lighter in color and of coarser grain than at the south, although, as compared with other fields, none of the granite found would be termed coarse grained.

Despite the extreme cold of the Vermont winters, the quarries are operated throughout the entire year, thus giving steady employment to over one thousand workmen.

QUARRY METHODS

Although the methods of working the sheet and boulder quarries differ in many respects, it is necessary in either case to partially free the stone from the bed or mass by channeling, to avoid unnecessary fracturing of the rock when blasting is resorted to. In this system holes are drilled in a line usually about 3½ inches apart from center to center, leaving a



Present-day Method of Drilling ''Plug'' and ''Foot Holes'' (Sullivan Drills in Boutwell, Milne, Varnum Quarry)

Method of Drilling ''Plug'' and ''Foot Holes'' before the day of the Hammer Drill

thin wall or web between them. A flat bit or "broach" is then substituted for the regular drill steel and with the rotating mechanism of the drill released, the wall is crushed to the entire depth of the drilled holes or to the thickness of the sheet. The lower photograph, page 362, shows the results of this process.

For work of this nature, the Sullivan "UH" (3⅝-inch) drills are used extensively, and with them 15 square feet of channeling per eight-hour day is by no means an uncommon record. They are mounted upon heavy adjustable quarry bars and equipped with a special broaching head, which permits the rotating mechanism to be thrown out of gear by simply loosening a set screw.

The amount of channeling necessary to remove a mass of stone is dependent upon its soundness and the number of free sides. As greater depths are reached more channeling is required, as it is often necessary to have the cut extend around four sides of the stone to be removed. On the fourth it is freed by drilling three Lewis holes in alignment with the grain and in the direction at which the break is to be made. After this the holes are reamed, before loading and firing. The right-hand cut on page 360 shows the marks of Lewis holes on one of the granite faces. By this method the break usually extends from one channel cut to the other, or to a seam or free end running parallel with it as the case may be. Sullivan "UB" (2¼-inch) drills mounted upon a special Lewis hole tripod meet these conditions satisfactorily and are largely used. The holes are reamed by cutting two "V" shaped grooves on opposite sides of the hole, to start the break in the proper direction. This is accomplished by inserting in the chuck of the drill a diamond-shaped cutting tool, the edges of which correspond in shape to the grooves to be cut. The drill is then operated as in the case of broaching, with the rotating mechanism released. In this manner grooves may be cut in several holes in perfect alignment.

PLUG DRILLING

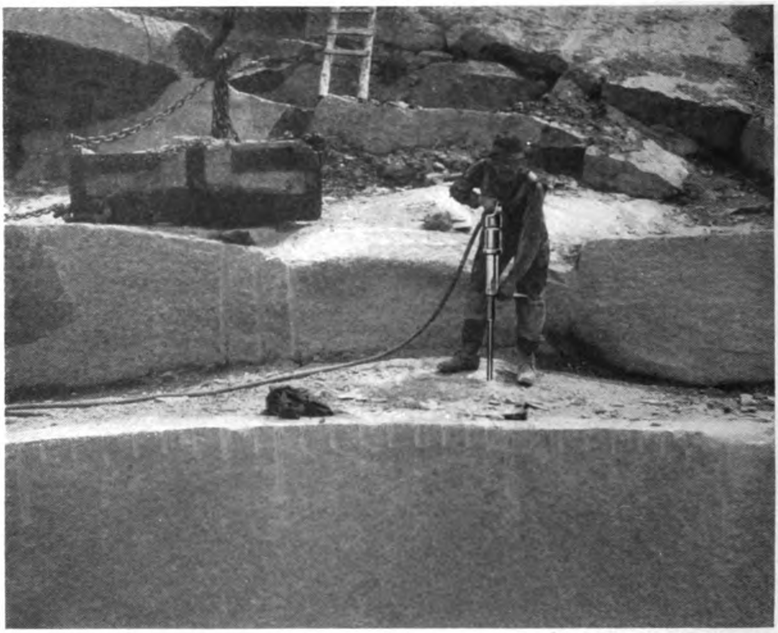
After the stone is loosened from the mass it is split to the proper dimensions by "plug" and "foot-holing." This consists of drilling a series of shallow "plug" holes about ⅝-inch in diameter and three to four inches deep, at intervals depending upon the character of the stone. When necessary larger and deeper "foot" holes are also drilled in alignment with the smaller ones but at greater intervals, to guide the break and to reduce the tendency of the break to run out of line, especially if there is frost in the stone. The edge of the block in the upper cut on page 362 shows these shallow and deeper holes. Steel "plugs" and "feathers" are then driven into the holes and the material split in a clear, smooth plane.

Air hammer drills are largely used for "plug" and "foot-hole" work, on account of their high drilling speed, efficiency and low cost of maintenance. One man with a hammer drill will do as much work in a given time as several men with hand hammers.

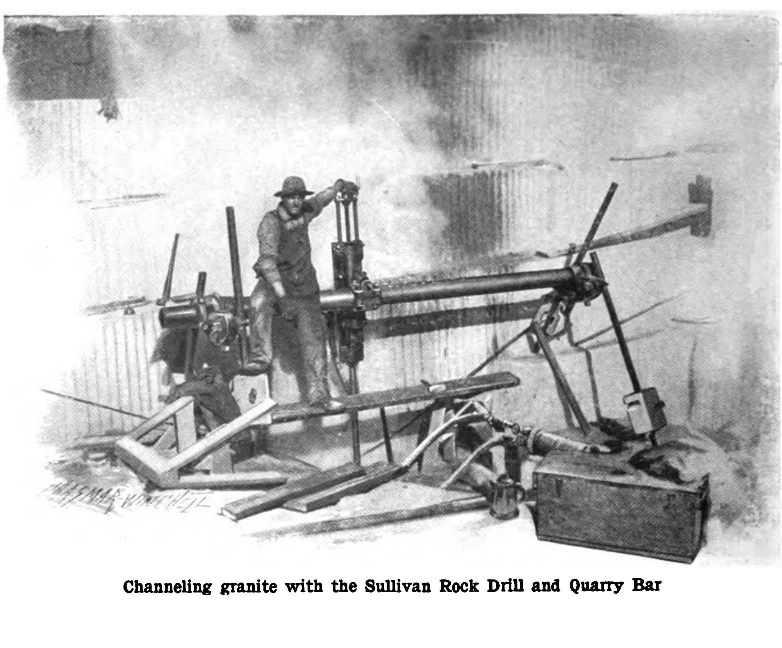
The Sullivan "plug" drill, on a test run, has drilled in these quarries 160 ⅝-inch holes, three inches deep, in one hour, while the Sullivan "foot-hole" tool with hollow drill steel will drill 1¼-inch holes 12 inches deep at the rate of one minute and thirty seconds per hole.

POWER

Compressed air is employed almost entirely for operating the reciprocating and hammer drills and practically all the quarries have independent air plants for this purpose. The air pressure in common use is 100 pounds per square inch, although the tendency is to increase this, when conditions will permit, to as high as 120 pounds. It is estimated that there are 75 miles of pipe and hose lines extending over the quarries, through which compressed air is conducted to the dif-



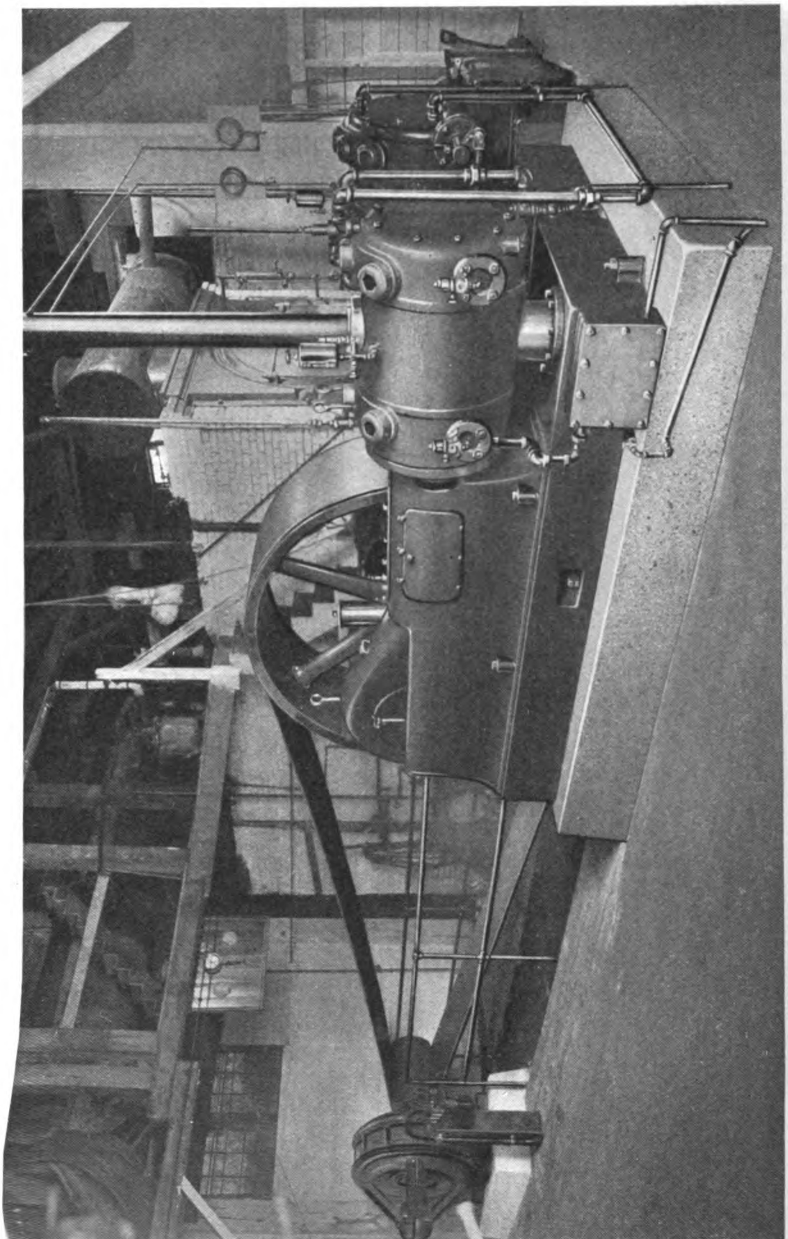
"Foot Hole" Drill at Work in a Granite Quarry



Channeling granite with the Sullivan Rock Drill and Quarry Bar

Sullivan Bushing Tool, Barclay Brothers

Sullivan Hand Surfacer Channeling across the end of a long block, Barclay Brothers



Sullivan "WJ" Air Compressor, Barclay Brothers, Barre, Vermont

ferent machines. Sullivan compressors are in extensive use. When steam is employed, the Sullivan straight line air compressor, combining moderate steam economy with low cost of installation, has become very popular, while the Sullivan belt-driven, duplex, two-stage type meets all requirements when electricity is the motive power. Steam power is largely used, but electricity, generated from water power, is rapidly supplanting it, due to scarcity of water at the quarries and the high cost of coal.

TRANSPORTATION

A problem which has always confronted the quarry operators is the disposition of waste stone, for as a rule, the ground adjacent to the quarry contains valuable granite. Incline railways are perhaps the most effective means of meeting this contingency, and are generally employed. A visitor to these quarries is deeply impressed by these mountains of waste stone, which in some cases are piled over one hundred feet high, and by the scores of derrick masts with their swinging booms. Some of the finest boom derricks in the world are to be found here, the largest, located at the quarries of the Boutwell, Milne and Varnum Company, having a capacity of over one hundred tons.

The completion of the Barre Railroad in 1888, connecting the quarries with Barre City, filled a long-felt want, for previously the rough granite had to be drawn by ox teams and horses to the finishing plants. Often as many as 20 horses were needed to haul a single block of stone. The railroad consists of 25 miles of standard gauge track, with spurs running into nearly every quarry. Its equipment includes several hundred flat cars and three heavy mountain type locomotives.

The railroad has a grade of five per cent or 264 feet per mile, on its main line, and nine percent, or 470 feet per mile, on the sidings into the various quarries. The highest elevation reached by the railroad is 1025 feet above Barre City. During the year ending June 30, 1909, it transported from the quarries over 200,000 tons of granite.

FINISHING PLANTS

The finishing plants, or cutting sheds, are located in Barre City, and give employment at the present time to 2350 workmen. Including the amount paid for labor in the quarries, this represents a yearly pay-roll for the industry of $3,000,000.

Space will not permit a lengthy description of the cutting sheds and the method of working the stone in detail, but a brief description of the granite plant of Barclay Brothers will serve as a representative. The photographs of tools at work were taken in this establishment.

SHOP OF BARCLAY BROS.

The granite finishing plant of Barclay Brothers is one of the largest, most modern, and best equipped in Barre City. The main building is 430 feet long by 60 feet wide, with three ells, aggregating 22,220 square feet in floor area. It is very strongly built, so as to handle stone of any size, and the machinery is so arranged that the work passes from one stage to the next in the most advantageous manner.

When the rough stone is unloaded at the plant it is handled by two overhead traveling cranes, adapted to cover the entire floor area of the main building. These cranes operate over the two railroad spur tracks, and are so arranged that they may be operated independently or as one unit if desired, with a combined capacity of 100 tons. Chains are used for handling the larger stone and manila rope slings for the smaller ones.

AIR POWER SERVICE

The introduction of compressed air in the granite finishing industry has entirely revolutionized it. Most of the drilling, surfacing, moulding, lettering and carv-

ing formerly done by hand is now accomplished by pneumatic machinery.

The block is first delivered to the battery of pneumatic surfacing machines (see page 367) located at the extreme north end of the plant and separated from the main room by a partition with large sliding doors.

On straight work these surfacing machines are adapted to cut the stone, from the condition in which it is received, while in the case of curved surfaces, lines are first chiseled or hammered around two or four edges, the balance of the surface being roughed down by plugging and bull setting to within two or three inches of the finished size before it may be worked to advantage by the machines. It is a fair estimate to say that one of these machines will do the work of six men surfacing by hand.

Here the block is formed to the required size, to a hammered finish. After the stone is surfaced it is transported by a crane to different parts of the works, where it is carved, sawed, polished and worked to completion.

Barclay Brothers' plant has in all about 70 pneumatic machines, ranging in size from the smallest of carving tools for delicate lettering and statuary to the large crane surfacers.

The air compressor is a Sullivan duplex two-stage, belt-driven machine, with a capacity of 1056 cubic feet of free air per minute, and is the largest belt-driven compressor in the district. The main working parts are oiled automatically by the "splash" method, and are enclosed to keep out grit and stone dust. A 150 H. P. motor transmits the power required to operate the compressor through a 28-inch double leather belt. The air is compressed to a terminal pressure of 105 pounds per square inch, and is piped to four large receivers, located in different parts of the plant. For the surfacing machines, plug drills and pneumatic polishing machinery the air is used at this pressure, but is reduced to 70 pounds for the smaller hand tools.

Sullivan hand surfacers are used for finishing the small surfaces which would be inconvenient to place under a larger machine. In connection with drills and channeling tools, they are used for such work as Lewis-holing, cutting mortises for cross tenons, cutting out solid sets of steps, buttresses and large rabbets. They are also used for channeling sinkages around columns and pilaster dies and forming sinkages for large cornices and gable stones, thus dispensing with much risk in cutting.

Electric power is used exclusively, there being nine motors ranging from 5 H. P. to 150 H. P. Four lathes for turning and polishing columns, balusters, vases, balls, etc., are located at the south end of the building, and also the gang saws and polishing machinery. The polishing machines are adapted for polishing a granite block of any size or shape.

A 125 H. P. boiler capacity is used, in connection with a blower system, for heating the plant in winter. The blower is also used, during extremely warm weather in summer, to create air circulation.

The pioneer Pirie sharpening machine is located in this plant. Operated by two men, it will keep 100 granite cutters equipped with cutting tools and will do the work of seven men, sharpening by hand.

Testing a "Plug" Drill

DRILL CORE PROBLEMS

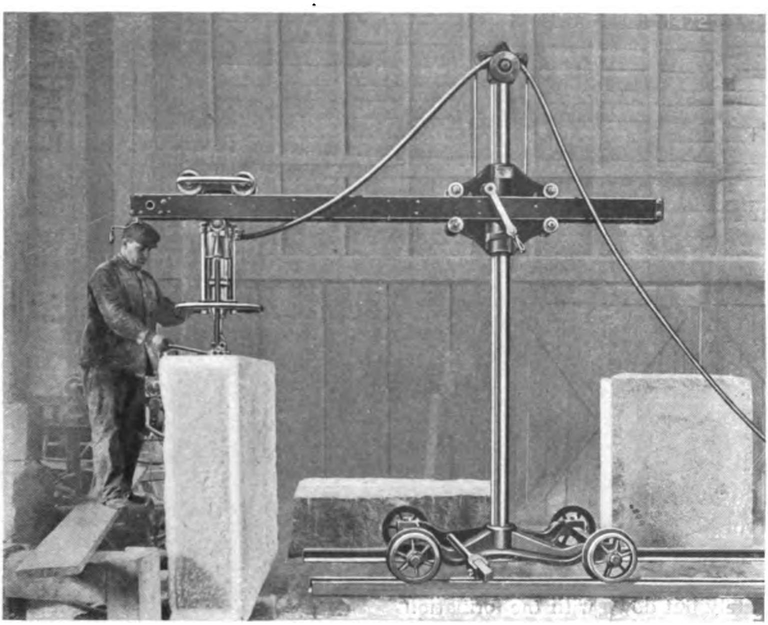
By Professor Alfred C. Lane, of Tufts College[1]

INTRODUCTION

The result of diamond drilling, which is the modern method of mineral exploration, is a series of cores or cylinders of rock. These cores are marked with bands or with lines. Some of these are due merely to the irregular wear of the drill. Others represent the bedding of successive layers of sedimentary rock. Exactly similar bands may represent the flow lines of lavas. Others may represent slaty cleavage, or other bandings due to pressure and shearing. Often these are small veins filled with calcite or other vein material.

The ends of these cylinders may be turned into a cup shape, or broken short off, or irregular. But very often they follow bedding or jointing or some line of weakness. If not, a sharp tap with a hammer will often break the core across, along some such plane.

The general tendency is to drill holes as nearly as possible at right angles to the bedding or that direction in which the rock parts most easily. There is more than one reason for this. For one thing, a greater thickness of strata is tested by a given length of hole. For another thing, the pieces of core are likely then to break off more nearly square across and move easily and smoothly up the core barrel (the tube in which they are contained) as the drill works its way into the rock. If they break obliquely they are likely to wedge and jam and get broken and ground into "sludge." It is always the object to get as much core as possible from the drill. Yet even with fair rock, from 1,000 feet drilled there is



Sullivan "D-28" Crane Surfacer, Barclay Brothers, Barre, Vermont

[1] Until recently State Geologist of Michigan.

often only 500 to 700 feet of core. If the cost per foot drilled is $2.50, the cost of the core will run from $3 to $4. It is, therefore, important to make as much as possible out of the core and the various lines and bands crossing it, whether they represent the bedding or represent displacements which may affect the record. The proper interpretation of these lines and bands is not always an easy matter. In the first place, the hole itself is liable to vary in direction. In the second place, generally speaking, we do not know the position of the core. A line or plane cutting it cuts it at an angle which can be measured. But in what direction that angle is from the core is usually not known. Little attention has been given to the marketing of core so as to know its exact position, — to know, for instance, the lowest side of the core taken from an inclined hole, though it is not impossible to do this.

If the core is crossed by lines of bedding, and we know from surface observations, what the direction of that bedding is, we can then tell how the core stands, and with that information can definitely determine the direction of other lines that cross it.

It is customary, as we have said, to put down holes at right angles to the dip, and often diamond drill holes are arranged in a series, so as to make a section across the formation. There is another advantage, beside the two above mentioned, in doing this, that errors are of less importance. The errors in thickness of a hole supposed to be put at right angles to the formation, but really deviating as much as 15° therefrom are but one-thirtieth and a deviation of one-third as much will have but one-ninth the error.

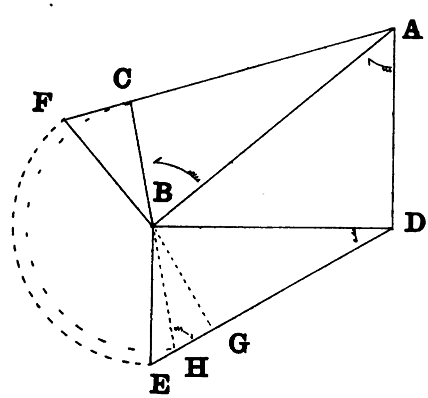
But occasionally, through unforseen quirks in the formation, holes are far from perpendicular to the formation to be tested. Of course, holes are sometimes deliberately put down with the formation to prove up the average quality of a chute, and put down vertical, even though the strata are highly inclined. In that case it is not always a simple job to compute just what the strike and dip of a formation are, even from a number of holes, though these are of vital importance, and there is a temptation to use approximate methods, beyond the limit of even approximate accuracy. I gave a discussion of a number of such problems that arise in my report on Isle Royale — Geological Survey of Michigan, Vol. VI, Part 1. 1899.

At the invitation of the editor of Mine and Quarry, I propose, in a series of papers to give as I have time, solutions of problems *which have actually arisen* in the past ten years. I shall try to make the solution so plain that any one who has similar problems can readily apply the same method.

Problem 1. At what angle will a plane (of fault or bedding) whose strike and dip are known cut the core of a drill hole which may be inclined a known amount in a known direction?

We will first solve this problem by drawing it out.

Let AD be the strike of the fault. Lay that off to have any convenient length and direction. Make on it as a side, erecting a perpendicular to AD at D, the right triangle ABD, taking B so



Drill Core Problem

that the angle DAB shall be equal to the difference in direction between the strike of the fault, and the direction of inclination of the hole. If, for instance, the hole is inclined 65° to N, 55° E, and the strike of the fault is N, 5° E, the angle DAB would be 50°.

Now, on BD make a right triangle BDE, with BE perpendicular to BD, such that the angle BDE is the same as the dip of the fault, which is known. This known angle and the fact that BE is perpendicular to BD determines E. Draw BF perpendicular to BA and equal in length to BE. Draw BC, making an angle with AB representing the inclination of the drill hole. If we should cut out along the heavy lines of the figure, A to F to B to E to D to A, and fold down ABF around AB and DBE around BD until BE and BF met, we should have a little model of the situation. The line BC would represent the drill hole and the plane from AD to the combined point FE, the plane of the fault. A line BG perpendicular to DE, which will represent the direction of dip, will be perpendicular to the plane of the fault, when thus rotated, and the angle the plane of the fault and the signs of it crossing the core make with the core, will be the complement of the angle BC will then make with BG. But as BG is perpendicular to the plane of the fault, the triangle BGC in which GC is in the plane of the fault, will be a right triangle.

Thence we have the rest of the construction. Lay off (cutting DE extended, if necessary) $BH = BC$ and the triangle, BGH will be similar to the triangle BGC of the model. The angle GBH = angle GBC of model, and the angle BHG is the complement of it and the angle sought.

The solution obtained by a careful drawing is generally as accurate as there is any use for, since it can be made as accurate as observations of lines crossing a drill core. Similar drawings may be used to solve many other problems.

For instance: We may in similar fashion connect the true dip and strike with the dip as it appears on a quarry wall running in some direction.

A trigonometric solution in numbers may be obtained by solving a series of right triangles corresponding to those we have constructed.

1. Let $AD = 1$. Then BA = sec of the angle DAB, the known angle between the strike of the fault and the direction of inclination of the hole. Call it s. $BA = \sec s = 1.56$ in the particular case drawn where $s = 50°$.

2. $BD = \tan s$ similarly $= 1.192$.

3. $BE / BD = \tan BDE$. This angle is the dip of the fault. Call it d. Then $BE = \tan s \tan d$. In the case drawn $d = 30°$, $\tan d = .577$ and $BE = .688$.

4. $BG / BD = \sin EDB$. Therefore, from 2, $BG = \tan s \sin d$. As drawn $BG = .596$.

5. $BE = BF$ and so the angle at BAF may be found since by 3 and 1, $\tan BAF = BF / BA$. Then by 3 $BF = BE = \tan s \tan d$ and BA in the triangle $ABD = \sec s$; so $\tan BAF = \tan s \tan d / \sec s = \sin s \tan d$.

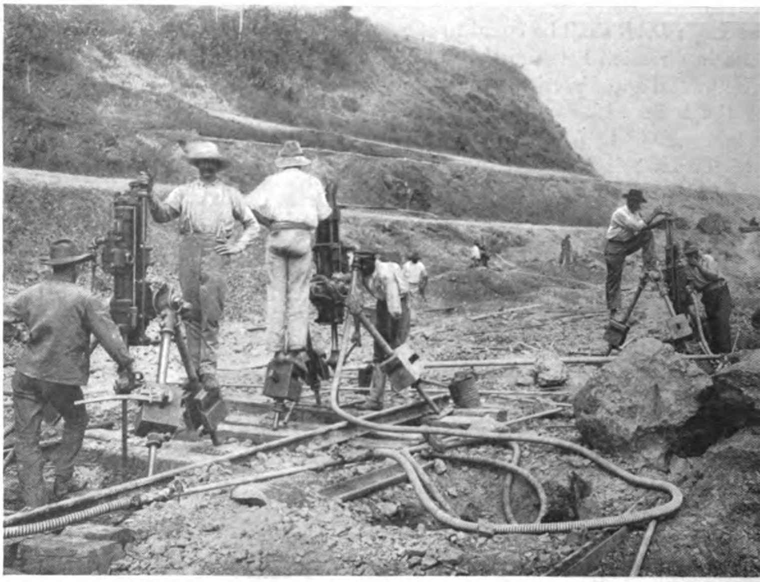
In the case before us $\sin s = \sin 50° = .766$ and $\tan d$ as in 3 is $.577$ and $\tan BAF = .442$. $BAF = 24°$ Call the angle $BAF = BAC$ a, then $\tan a = \sin s \tan d$.

6. By a standard trigonometric formula any two sides of a triangle are as the sines of the opposite angles. It may readily be proved by dividing it (ACB for instance) in two right triangles by a perpendicular dropped from (C) the remaining angle to the other side. Hence $BC / BA = \sin BAF / \sin BCA$. But it was found by 1, that BA is $\sec s$; this angle BAF (we call it a) was found by 5. $BCA = 180° — a —$(inclination of hole ABC) (call this i). Therefore, since $\sin (180° — a — i) = \sin (a + i)$ $BC = \sec s \sin a / \sin (a + i)$. In this case draw $BC = 1.560 \times 0.405 / 1. = .632$.

7. Hence we have the angle sought, BHG, which is the complement of $GBH = GBC$; $\sin BHG = BG / BH = BG / BC =$ (by 4 and 6) $\tan s \sin d / \sec s \sin a / \sin (a + i) = \sin s \sin d \sin (a + i) / \sin a$, where a by 5 is $\tan^{-1} \sin s \tan d$. If the hole is not inclined $BC = BF$ and $BH = BE$. $i = 90°$ and BHG complement of 90°.

With a slide rule this series of triangles may be solved by one used to working it in a few minutes, as short a time as required to make a careful drawing.

In the case drawn $\sin BHG = (BG = .596) / (BC = .63) = .946$, therefore, angle $BHG = 70°$.



AT PANAMA

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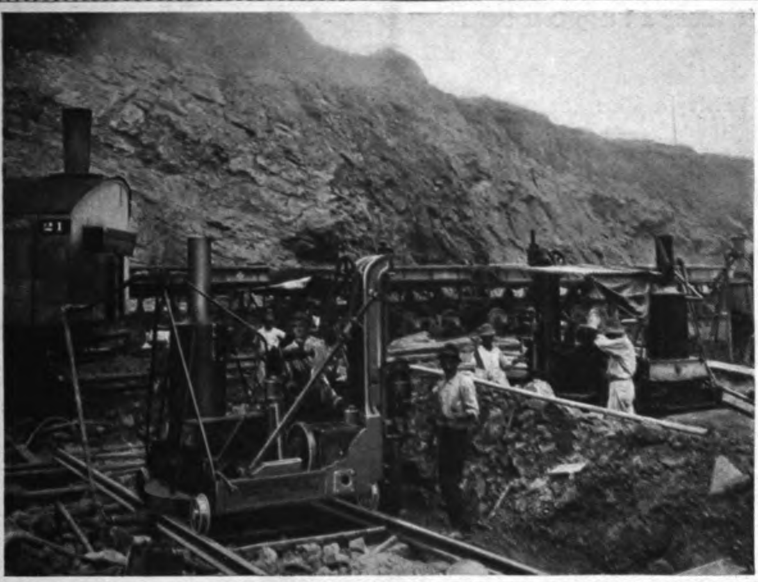
MINE AND QVARRY

VOL. IV. No. 4 APRIL, 1910

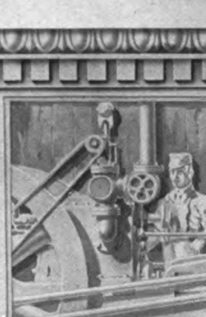


CHANNELING IN THE PANAMA LOCKS

WORKING A STEEP COAL SEAM

CHANNELED WALLS AT PANAMA

A QUEBEC MARBLE QUARRY



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MINE AND QUARRY

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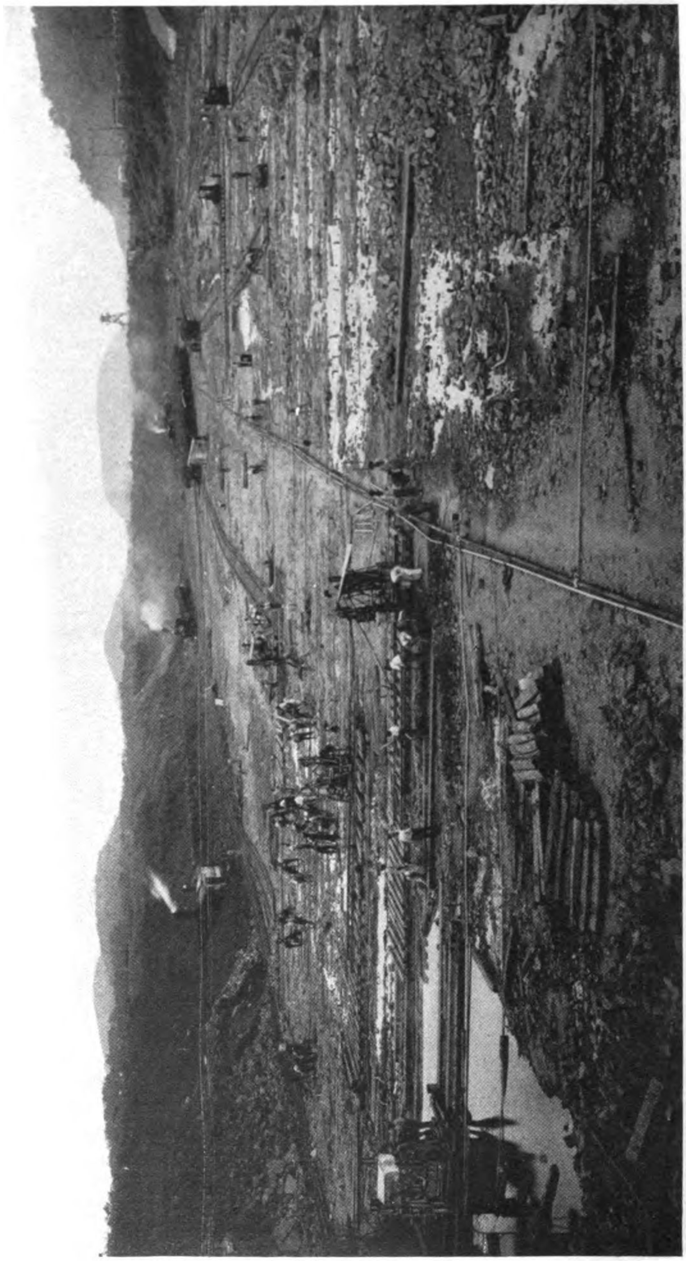
Readers are requested to notify MINE AND QUARRY of any correction or change in address.

[The article on page 384 constitutes the seventh in a series describing the marble deposits of North America and the methods employed in their development. The articles which have already appeared in MINE AND QUARRY are "Quarrying Marble in Georgia," November, 1906; "The Marble Industry in New York State," February, 1907; "Alabama Marble," October, 1908; "Vermont Marble," Part I, March, 1909; Part II, June, 1909, "Quarrying Marble in Tennessee," September, 1909. — EDITOR.]

With this number MINE AND QUARRY completes its fourth year of publication. The editors take this occasion to thank the many individuals, who have contributed articles or information to these columns, for their assistance and courtesy, and to thank readers for their continued interest in the publication. The past four years have seen some interesting developments on the mechanical side of mine, quarry, and engineering work. They have seen many new applications of existing methods. This paper has endeavored to present a few of these developments and applications in such a way as to be of practical value to its readers. It intends to pursue the same line of enterprise during the coming year.

The editors would encourage readers to present their problems to MINE AND QUARRY for solution, and to use it as a bureau of information. Contributions relating to mining, quarrying, or engineering practice will be welcome.

The "post puncher," described in this issue, meets a number of requirements in coal mining practice, for which, hitherto, no satisfactory mechanical means has been available. The "post puncher" will probably be used, to the largest extent, for mining in steeply pitching veins, in which chain cutters or pick machines cannot be handled. It is also proving its value in seams containing partings, on account of its ability to mine at any height in the coal. The "post puncher" can also put in minings and shearings from the same mounting without removing the machine, a great advantage when the coal must be cut vertically as well as horizontally, in order to shoot properly. Other machines, known as column shearers, or radial coal cutters, have been on the market for some time, modeled rather closely on the lines of the standard rock drill. The "post puncher" has some of the general features of a drill, but is designed and built especially for service under coal mining conditions, and for this reason, as well as for certain patented features, superiority is claimed over other similar machines.



Completed excavation for the Pedro Miguel locks; Sullivan channelers and rock drills at work.

CHANNELED WALLS AT PANAMA

Special Correspondence

A valuable element in the use of stone channeling machines for cutting rock walls is the fact that neither the walls themselves nor the ground adjacent to them is broken or shaken, as would be the case if the walls were formed by drilling and blasting. This factor is of great importance in formations which are already irregular and broken, and which must be used as foundations for heavy structures. Such ground, if disturbed by blasting, would be likely to shift or settle, either at the time of construction, or later, with resultant damage to the structures carried by it.

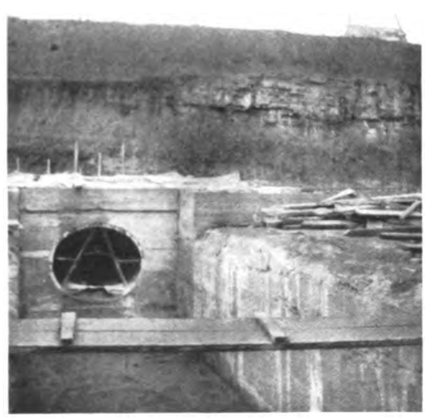
A current instance of this point, having more than ordinary interest, is found in the construction of the great locks of the Panama Canal. Readers will recall that the 85-foot summit level of the canal, extending 30 miles from the Gatun dam to Pedro Miguel, at the Pacific end of the Culebra cut, is to be reached at each end by three stages, the locks being arranged in pairs. On the Atlantic side, the three lifts are combined in one continuous system, each stage representing 28⅓ feet. On the Pacific side, about two miles intervene between the first step down at Pedro Miguel and the second and third locks at the Mira Flores dam.

The construction of these locks constitutes one of the most critical engineering problems of the canal, and the methods employed in meeting the local conditions and in handling material are especially worthy of study.

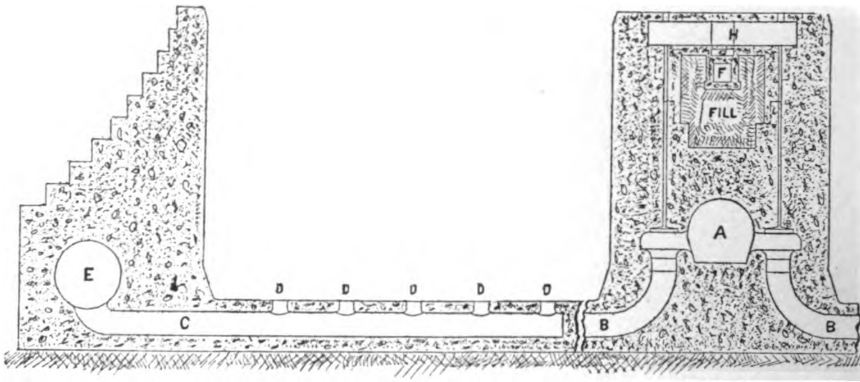
As indicated in the sketch on page 372, the locks are to be supplied with water from conduits running the length of the side and center walls. The proposed rate of rise in water level is three feet per minute, by which the locks will be filled in about 13 minutes. In order to minimize the surging which this rapid change in level might occasion, with possible damage to vessels in the locks, the plan was adopted of admitting the water through the floor. For this purpose there will be in each chamber eleven lateral culverts leading from the conduit in the side wall, and ten from the center conduit, alternating and spaced at intervals of 32 and 36 feet. From each culvert there will be five wells or openings. The main conduits are from 18 to 22 feet in diameter, while the laterals are elliptical, 6½ feet high and eight feet wide.

CHANNELING THE TRENCHES

This design necessitates cutting 21 trenches in each chamber, about 100 feet long and 13 feet deep. The rock is of an extremely variable nature, ranging, at Gatun, from hard tufa containing shell fossils, to soft sandstones, within a few feet. At Pedro Miguel a hard blocky trap occurs, somewhat like the diabase encountered in the railroad cuts through Bergen Hill, in Jersey City, but adjoining it, within 50 feet, are beds of indurated clay.



A lateral trench, showing channeled walls.



Cross section of lock chamber and walls, Gatun Locks.

A Culvert in center wall.
B Connections between center and lateral culvert.
C Lateral culvert.
D Wells opening from lateral culverts into lock chamber.
E Culvert in side wall.
F Drainage gallery.
G Gallery for electric wires.
H Passageway for operators.

From the Canal Record.

Under such conditions it is very desiraable that the floor between the trenches shall be disturbed as little as possible. In order to eliminate the shattering effect of blasting it was decided to cut the side walls of these trenches with stone channeling machines. For this work Sullivan rigid-head channelers with 8-inch cylinders were adopted and 24 of these machines are now on the Isthmus. The photograph on page 370, shows six channelers at work at Pedro Miguel, and gives an excellent idea of the lock site, in which the excavation was nearly completed at the time the picture was taken.

The channelers are run by compressed air from the power plant at this end of the Culebra cut, and are equipped with air reheaters. The solid "Z" shaped bit is used altogether, owing to the "wild" character of the ground.

Page 373 shows a channeler at work at Mira Flores. Here the air-pressure is very low, 40 pounds. The channelers cut to a depth of 10 feet, and average 120 feet per eight-hour shift.

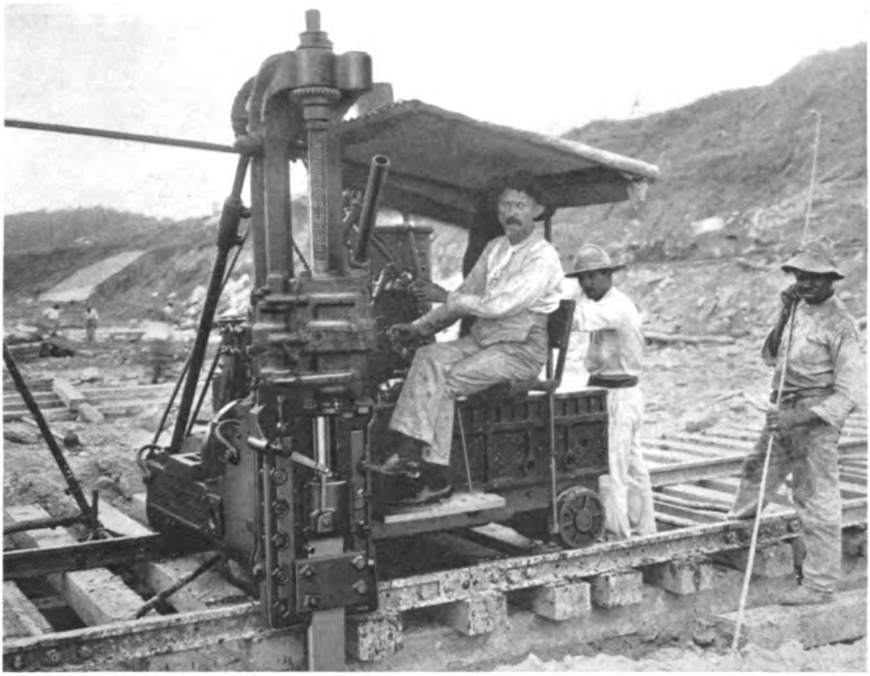
The cut on page 393 shows a channeler at Gatun, equipped with a boiler. The machines here are run by steam, as no air-power is available.

In addition to preserving the surrounding rock intact and unshaken, the use of channelers has resulted in a large economy of concrete, owing to the fact that the excavation is confined strictly to line.

The rock between the channel cuts for the lateral culverts is drilled with Sullivan $3\frac{5}{8}$-inch drills and shot lightly, to break it up for excavation. As soon as the rock is removed the forms for the culverts are placed and the trench filled with concrete. The photograph on page 371, shows one of the trenches, with the culvert and concrete work partially completed.

The total amount of channeling to be performed in the locks is about three quarters of a million feet, and includes cutting trenches beneath the curtain walls and across the forebay at Gatun. In these trenches cut-off walls are being built to divert underground waters, whose presence has been discovered, from the area below the locks. In this case also it was of the greatest importance that the adjacent ground should not be disturbed by blasting, so as not to affect the stability of the foundations for the great concrete lock walls.

The channeling of the lateral trenches in the upper locks at Gatun is completed, and will be taken up in the intermediate and lower flights as soon as the excava-



A Sullivan channeler at Mira Flores.

tion is sufficiently advanced. At Pedro Miguel the trenches are about 90 per cent channeled, while at Mira Flores this work is progressing rapidly in the upper locks.

DESCRIPTION OF LOCKS

Excavation for the locks began in the fall of 1906, and is now about 60 per cent completed. Another year will be needed at Mira Flores to remove all the material down to floor level. The placing of concrete in the floors and walls of the locks at Gatun and Pedro Miguel began about September 1, 1909, and is progressing rapidly under the efficient system which has been installed. Up to March 12, 1910, 253,511 yards had been placed at Gatun, out of an estimated total of 2,096,000, and the work is proceeding at the rate of about 2,800 cubic yards per day. At Pedro Miguel, about 71,000 yards had been placed up to the same date.

The locks will have a uniform inside length of 1,000 feet, a width of 110 feet, and a depth on the miter sills of 41⅓ feet of water when the surface of Gatun Lake is at its theoretical normal height of 85 feet above the ocean. The side walls will be 50 feet thick at the floor line, and from a point 24⅓ feet above will be staggered on the outside face to a summit width of eight feet. The central wall, between each pair of twin locks, is to be 60 feet thick, and from a point about half way up will be narrowed toward each face to provide a tunnel or space for drainage, electric cables for the valve and gate machinery, etc. See cross-section sketch on page 372.

Sullivan "Post Puncher" starting a mining in the Coal Creek Mine.

WORKING A STEEP COAL SEAM

MINES OF THE PACIFIC COAST COAL CO. AT COAL CREEK, WASHINGTON

WRITTEN FOR "MINE AND QUARRY" BY AUSTIN Y. HOY[1]

The Pacific Coast Company of Seattle owns and operates through subsidiary companies (The Pacific Coast Steamship Company, Pacific Coast Railway, and Columbia and Puget Sound Railroad) over 26 steamships in the coastwise trade with Alaska, British Columbia, and California points, and about 165 miles of railroads. This company built the first railroad in the state of Washington, 38 years ago, and is to-day one of the largest concerns of the Pacific Northwest.

The operation of these steamers and railways requires a large amount of coal. When the Alaska trade is in full swing, over 3,000 tons daily are used to supply the demands of this traffic.

LOCATION OF MINES

The Pacific Coast Coal Company (another subsidiary incorporation) owns and operates coal mines at Franklin, Black Diamond, Coal Creek, and Burnett, all less than 30 miles south and east of Seattle. The Coal Creek mine adjoins the old Newcastle mine, which was opened some 30 odd years ago, worked to a depth of 2,000 feet, to the boundaries of the property, and is now closed down.

LABOR

During the last decade, the production of coal has increased so greatly in the United States that the employment of a large percentage of unskilled men as miners has been necessary. Since native-born Americans rarely become coal miners, this labor has been supplied largely by immigration from Italy and the Slav countries, where practically no coal is mined. These circumstances have necessitated the extensive use of machines for doing the work formerly done by skilled miners, namely, "mining" the face of the coal, so as to avoid "shooting off the solid" and the consequent production of great quantities of slack and unmarketable sizes of coal.

[1]Spokane, Washington.

CHARACTER OF SEAMS

Chain machines and compressed air "punchers" have solved this question under the conditions existing in most of the coal fields of the United States, but in some places the seams pitch so sharply as to render the use of these types out of the question.

This was the situation that confronted the Pacific Coast Coal Company at the Coal Creek mine. Skilled miners were almost unobtainable, and as the coal is a non-coking, semi-bituminous variety, adapted for steam and domestic purposes, shooting off the solid made much unsalable product.

Accordingly, over two years ago, experiments were begun to increase as much as possible the percentage of lump (which brings about $2.00 a ton more in the Seattle market than the smaller sizes).

Compressed air post mining machines of the radial type were installed and it was found that after a mining was put in with these machines, the coal could be sent down the chutes with only a little pick work, and without any powder, except an occasional light shot at a corner or to shoot out a "nigger head." In fact the powder consumption was reduced over 95 per cent.

The lump coal was increased in this way from about 25 per cent to about 60 per cent, and the practical elimination of powder made the mine much safer.

The first machines used developed serious mechanical troubles, due to the unusual stresses imposed by frequent falls of coal. About a year ago the company therefore accorded a thorough test

"Post Puncher" in the Coal Creek Mine, with 80-inch extension in use.

Setting up a "Post Puncher" in a 38-degree seam.

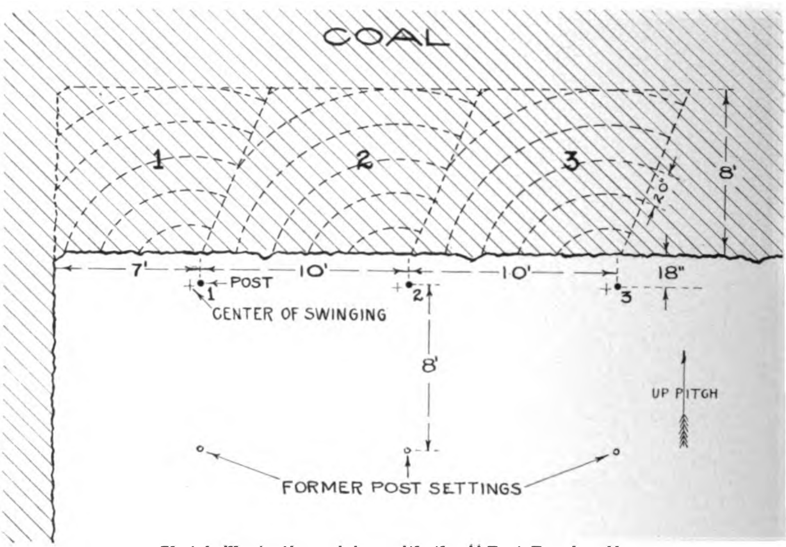
to the Sullivan Post Puncher, and after several months' use an order was placed for 30 machines of this type and make.

THE POST PUNCHER

The pictures on pages 374 and 376 show a "Post Puncher" in operation in the No. 4 vein of the Coal Creek mine, where the coal is 4½ feet high, and pitches at an angle of 38 degrees. As this type of mining machine is practically new in American practice, a brief description may be of interest.

The "Post Puncher," resembles a rock drill in the fact that it is mounted on a post or column, and uses length bars or steels of various lengths, in doing its work. It resembles the "puncher" or pick machine in its ability to mine across the face, or to shear a room from top to bottom. For this purpose the machine and shell are mounted on a gear segment, controlled by a worm and crank. In mining, the operator swings the bit in an arc back and forth across the face. By loosening one nut, the segment may be set in a vertical plane, and a shearing cut made in a similar manner.

This feature is a very great convenience when the coal will not shoot readily unless both mined and sheared. A valuable feature of the "Post Puncher" is the fact that the machine does not swing around the post, but around the center formed by the socket, in which it is clamped, about six inches from the post. It is, therefore, unnecessary to set the column exactly square with the intended mining, but the machine may be set in a few seconds to mine wherever desired, regardless of careless placing of the post. This is a patented feature, possessed by no other similar machine.



Sketch illustrating mining with the "Post Puncher."

Dismounting the machine when swinging from the mining to the shearing position is also unnecessary.

The cylinder and valve motion embody other novelties. The front head is solid with the cylinder, thus eliminating the complication of side rods. When the coal is missed, the piston will overrun the front port and stop, thus obviating damage to the front head. This overrunning occurs very seldom with a skilled operator, but the delay attendant on feeding the machine against the coal, so that it will start again, is nothing to the delay due to breakage that would occur eventually if the piston could strike the front head. The cylinder is made of steel, to resist the heavy shocks and strains received from falling coal. Felt packing of a very durable character and having an adjustable gland, is employed. A combined shell adjustment and stop, to prevent feeding too far, and a rotation without springs, provided with five round steel pins or pawls, are other interesting features of the "Post Puncher" design.

The exhaust cap is so arranged as to throw the air in any desired direction to avoid raising dust. The extension rods or length bars range from 20 to 100 inches in length, and are tapered at both ends, one to fit the chuck and the other to receive the bit holder. This bit holder has tapered holes for from three to seven chisels or bit points, as shown on page 374. A solid bit may be used instead, depending on the nature of the cutting.

The mining may be put in at any desired height in the seam, so as to mine in fire clay, the coal itself, or in a dirt band, by raising or lowering the clamp on the post. In the illustrations the machine is shown mining in a band of bone and clay near the roof, and is accordingly above the segment. In the six-foot "Muldoon" vein, the impurities are lower in the seam, and the machine is hung below the segment.

METHOD OF OPERATION

The rooms are driven 45 to 50 feet wide. The first cut is made from a post set seven feet from the left rib and about 18 inches from the face. See the sketch on this page. A mining eight feet in depth is put in, using an extension bar 80 inches

Loading Coal in Muldoon Vein. Note man at chute in rear.

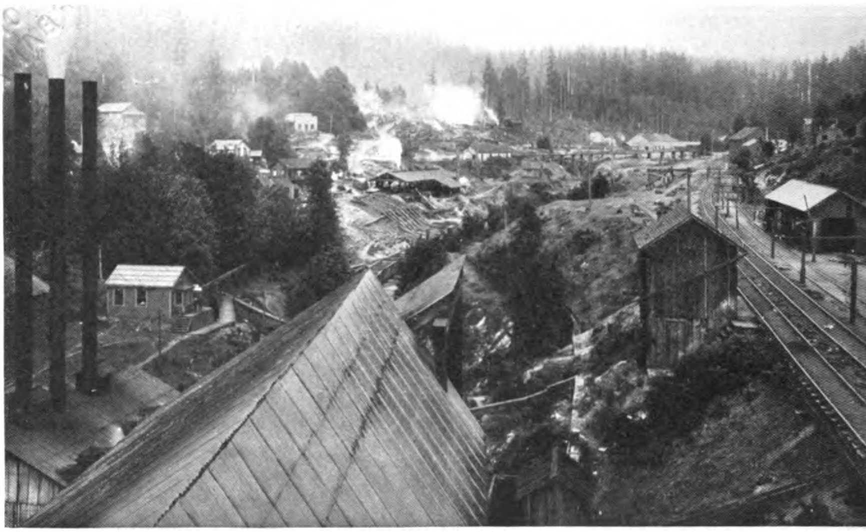
long. The chuck enters the cut, which accounts for the mining being deeper than the length of the extension. After the 80-inch extension has been swung, a 100-inch bar is used to square up the cut. One man operates the machine, swinging it by means of the worm crank with one hand, and feeding the cylinder forward two or three turns with the other, at each end of the swing.

Although the cuttings fall out of the cut without scraping, due to the pitch, a helper is required to set up, pick down coal, etcetera. When the operator is completing the left rib cut, the helper sets up a second post about 10 feet from the first one, or about 17 feet from the left rib, and 18 inches from the face. Upon finishing the rib cut, the machine and swinging attachment are transferred to the second post with only a few minutes' delay. While the operator is making the second cut, the helper takes the first post down and resets it about 27 feet from the left rib for the third cut, and so on, until the face is crossed. Only a half swing is used, so that the operator is protected by the unmined coal, as well as by the machine itself, from the coal loosened from the face by the mining.

The machine and posts remain in the room at the face until the room is completed, for there is no shooting of the coal that can injure the machine nor any loading (as in a flat seam) that the machine would interfere with. Hence there is no waste of time due to moving, except from post to post, and little heavy lifting. Two men can set up with ease, as the heaviest parts (the machine and shell) weigh only 225 pounds.

ECONOMIC RESULTS

These machines average about 300 square feet in an eight-hour shift, or from



Top works and town of Coal Creek.

Bottom of slope, Coal Creek Mine.

45 to 55 tons per machine per shift, according to the height of the coal. While, as stated above, the reason for the installation of these machines was solely to increase the proportion of lump coal, even if the cost of mining was increased, the results point strongly toward a material reduction in the cost of mining, after all interest, depreciation, power, pipe line, and maintenance charges have been made against the machines.

In shooting off the solid, the former method, a yardage system of payment was used, the rate being $9.50 for a 50-foot room. Three men worked together furnishing their own powder. The reason for using a yardage and not a tonnage system, was because of the impurities in the seams, and the pitch. The coal and debris go down the chutes together to the slope, thence in mine cars hauled by electric locomotives to the surface and through a preparing plant of picking tables and washers.

GENERAL MINING FEATURES

The mine in which these machines are used is a new one and is worked from a slope 600 feet deep, sunk on the pitch of the seam. It adjoins an old mine of the same company, operated through a tunnel. The old mine is nearing exhaustion, but is still furnishing about 600 tons daily.

The new mine is to be worked upon the retreating room and pillar system. The entries have nearly reached the boundaries of the property at this writing, and when this is accomplished they will appear as shown by the sketch plan on this page.

A Sullivan straight line two-stage steam driven air compressor with a capacity of 1,843 cubic feet of free air per minute has just been installed at these mines, and a new pipe line laid. The management now plans to put the new mine on one-half capacity (600 tons daily), operating about 12 Sullivan Post Punchers. Later on, when the old mine is exhausted, the compressor and machine plant will be doubled and the production increased to 1,200 tons.

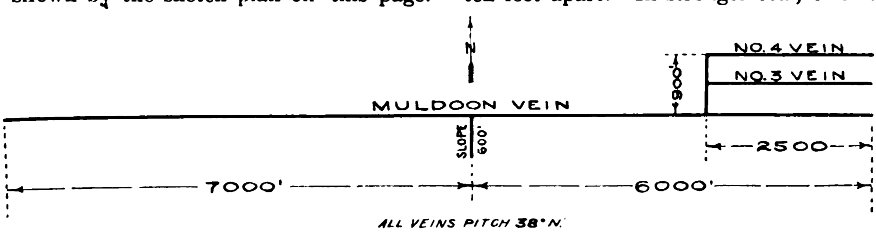
The writer's thanks for data used in preparing this article are due Mr. J. J. Jones, superintendent of the Coal Creek mine, Newcastle, Washington.

APPLICATIONS OF THE "POST PUNCHER"

While the use of Sullivan "Post Punchers" is particularly adapted to heavily pitching seams, they are also useful in flat seams, where it is desirable to mine in a dirt band above the floor or near the roof. In seams where the cuttings do not fall from the mining by gravity, the helper keeps the cut free by means of a long handled flat shovel or a scraper.

In some fields these machines have been successfully used for driving entries, and for shearing they can hardly be excelled, especially when both mining and shearing cuts are required, owing to the quickness and ease with which the setting may be altered for either purpose.

From the above article it has been noted that the Post Puncher was used at Coal Creek with only a half swing, and that the posts were therefore set only ten feet apart. In stronger coal, or in a



Plan of the Coal Creek Mine.

flatter seam, where the danger to the operator and machine from falling coal is less serious, the machine is used to cut on both sides of the post, from the same setting, having a maximum capacity of about 18 feet of face from one set up. To keep the ribs or side walls of an entry or room straight, the bit is swung back and forth across the corner, gradually advancing it with the feed screw until the angle is square. Or a hole may be drilled at the extreme end of the swing to the full length of the feed screw, then the bit cranked back and the mining made up to this hole at each swing.

WEDGING DOWN COAL

The Post Puncher may also be employed for wedging down coal, in mines where the use of explosives is prohibited. After undercutting and shearing, the machine drills a hole about three inches in diameter at the top of the seam. An ordinary bit may be used for this purpose. The hole is then scraped out and a compound wedge (plug and feathers) inserted. The machine may be swung around the post if necessary to give access to the hole. When the plug and feathers are placed the machine is swung back to position opposite the hole, and a special hammer inserted in the chuck. The air is gradually turned on, the hammer striking the wedge with increasing force until the coal breaks down.

RAISING A MINE SHAFT

Contributed

It sounds anomalous to the layman to hear of a shaft which is driven up from below, instead of downward from the surface. Yet this has become a widely accepted method, under certain conditions, and has many advantages over the orthodox system.

Generally speaking, shafts are "raised" when a new opening is desired for a developed mine, or when one of two or more shafts, connected by drifts or levels, is to be extended. The method employed consists in driving to a point directly under the proposed opening, whence a small raise is started, which is enlarged later to full size. The muck is dropped into cars on the lower level through a chute, and hoisted through the existing shaft, or used to fill up rooms or workings from which the ore has been removed.

In the Lake Superior district, instances are on record of three compartment shafts which have been raised in their full size and timbered at the same time, instead of driving a small raise and stripping it later. In these cases the timbers were placed with the aid of a small hoist, installed at the bottom level. To prevent damage to the timbers, two compartments were kept full of muck. The third was used as a manway and for ventilation.

In the soft iron ore fields of northern Michigan, raising is sometimes employed to extend a single shaft driven in the foot wall. At a convenient point on the bottom level, a winze is sunk in the ore to the proposed depth, and from its foot a drift is run to a point below the center of the shaft. Raising is then started, a chute built, and the dirt handled through the winze, where it is either stored or hoisted from the old bottom level. Ventilation is provided by a small blower.

Sinking the winze in the soft ore is an easy and simple task, and cannot be classed as dead work.

ADVANTAGES OF THE SYSTEM

Much time and labor is saved, by the raising system, in handling spoil. After a round of holes has been shot in a shaft sunk by the usual method, it is necessary for shovel-men to load the spoil out, before the drills can get to work again.

When raising, no shoveling at all is required, as the muck falls down the chute and is loaded by gravity into the mine cars, in which it is hoisted directly to the surface, or from which it is dumped in a worked-out chamber. No time is lost by the drill men in waiting for the muckers, since the overhead face is always free, and ready for the next round, as soon as the powder fumes are blown out and enough spoil dropped down the chute to permit entrance. The number of rounds that can be drilled per day or month is therefore much greater in a raise than in a shaft sunk in the customary way.

When a shaft is in active production, it may be extended by an upraise from a lower level without interruption to the regular hoisting service, and without placing the men engaged in the extension in danger from falling material or from accidents to the hoist. If in water bearing ground, the pumping problem is much simplified — in fact, the "sinking pump" is eliminated, just as shoveling is eliminated.

HAMMER DRILLS

Another and equally important advantage lies in the use of air feed hammer drills for raising. Before their use became general, great loss of time and much heavy labor were involved in handling piston drills. Much time and work were expended in hauling the drill and its mounting up and down the raise.

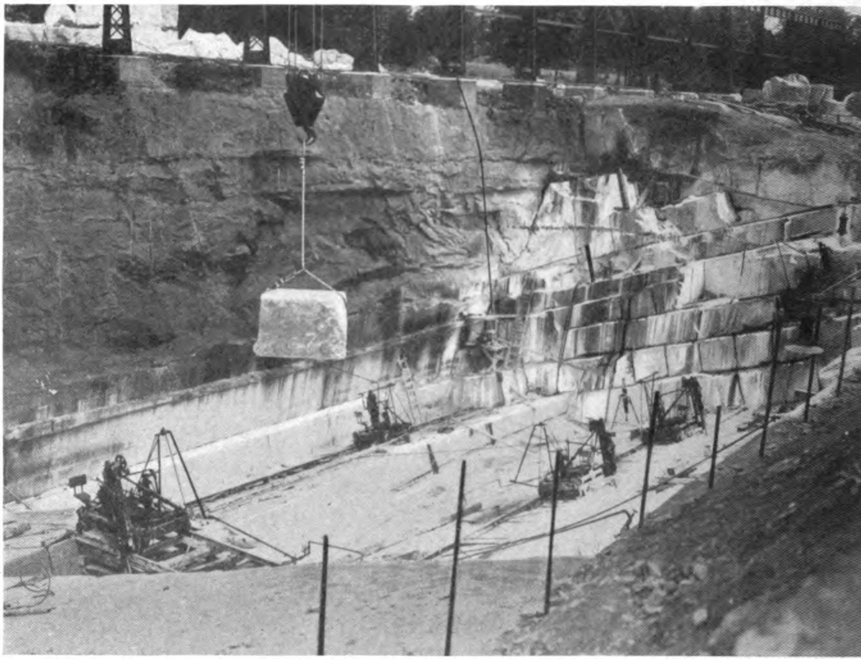
The advent of the light "one-man" hammer drills, which require no mounting and no support other than a footing of muck or a block on which to rest the air feed cylinder, has occasioned remarkable economy in work of this character.

In addition to the gain in actual drill-

Raising with a Sullivan Stoping Drill.

ing time made possible by the fact that no "set up" of a separate mounting is required, there is an increase in efficiency on account of the ability of the runner to point his holes in exactly the right direction to pull the rock to the best advantage.

Stoping drills, including those of the Sullivan "D-21" pattern, are used for this class of work with eminent success in the Lake Superior district. In the winzes driven in ore, above described, Sullivan "DB-19" air hammer hand feed sinking drills have also proved satisfactory. In a later article, more specific data will be furnished as to the use and performance of hammer drills in work of these kinds.



The Main Quarry Pit, Missisquoi Marble Co.

A QUEBEC MARBLE QUARRY

Special Correspondence

The property of the Missisquoi Marble Company comprises about 300 acres of quarry lands, at Phillipsburg, in the province of Quebec, two miles from the Vermont boundary line, and bordering on Lake Missisquoi, one of the northern arms of Lake Champlain. This deposit of marble is apparently independent, being over 130 miles distant from those in St. Lawrence County, New York, and more than one hundred from the Vermont marble district about Rutland.

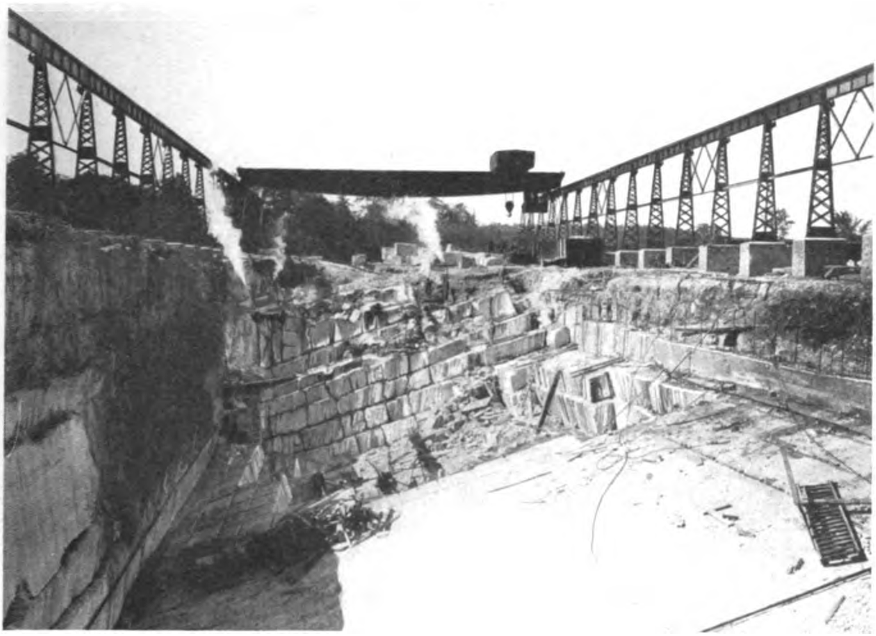
Thorough core drilling has shown that the marble formation covers practically the whole of the company's property, and that it is sound and of excellent quality. Its chemical composition is as follows:

	Per cent
Calcium carbonate	96.34
Calcium sulphate	0.12
Magnesium carbonate	0.49
Silica	1.18
Iron oxide and alumina	.80
Undetermined, etc	1.07

The stone is of handsome appearance, being gray with green veins, and cream with green veins. There is also a layer producing green with a little pink.

Tests were made in a very systematic manner upon samples submitted for the purpose to Prof. H. M. Mackay of the department of Civil Engineering at McGill University, Montreal.

The compression tests were made in the Wicksteed machine upon two-inch cubes. The "Windsor Gray" samples withstood a pressure of over 21,000 pounds and the "Eureka" cream color stone, a pressure of nearly 23,000 pounds per



The Quarry and Traveling Crane.

square inch. This compares favorably with the better grades of granite. The absorption of moisture, as shown by a test upon roughly broken samples, is remarkably low. The specific gravity is 2.71, or 169.5 pounds per cubic foot.

These marbles are employed extensively for monumental purposes and for interior decoration, and more recently have been used for building exteriors, with highly satisfactory results.

The deposits lie in regular beds or layers, sloping at an angle of 45 degrees. The surface material or overburden is only a few feet in thickness, making stripping a simple problem. The views on this and the preceding pages show how the quarry is being developed. The property was originally purchased about 15 years ago, by the Phillipsburg Railway and Quarry Co. It was not until 1906, however, that work was begun, and in 1907 the present owners acquired possession. Since that time, progress has been rapid.

Quarry Methods

The marble is quarried with nine Sullivan swivel-head channeling machines, operated by steam through swivel piping. Five of these are of the Class "6½" type, two Class "Z," with seven-inch engine cylinders, and two Class "VX," for light work. These channelers possess adjustments enabling them to cut at any desired angle, so as to enlarge the quarry floor by "tunneling," as illustrated in the left-hand wall, above, or to cut out ends and corners, illustrated by the left-hand machine on page 384. The wall cuts are put in at an angle of 70 degrees. These channelers cut ordinarily to a depth of six feet, and 63 square or channel feet are considered a fair day's work in this hard, dense marble. The blocks are

broken away from their beds by wedges, driven in holes bored in line with the dip by Sullivan Rock Drills, mounted on a quarry bar. A Sullivan "foot-hole" hammer drill is used for pinning down track and other miscellaneous purposes.

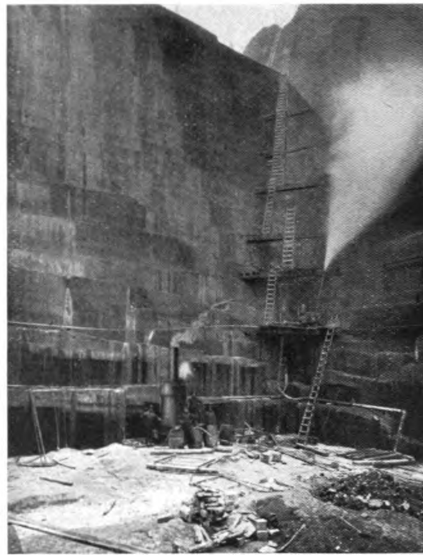
A novel method is in vogue for handling the blocks. Instead of the customary boom derricks, or cranes, a traveling electric crane is installed with a span of 100 feet and a lifting capacity of 30 tons. The runway is 460 feet long. This crane provides an unusually rapid and economical means of loading cars for the finishing plant and of moving the channelers and drills about the pit. A second crane is now being installed in front of the mill to handle the stone to and from the saws, and in the finishing departments.

From the quarry, the blocks go to the storage yard, which is under a traveling steam derrick, and connects with the mill and finishing works. The mill contains six gangs of saws and a steam-driven air compressor, which furnishes power for pneumatic tools of various kinds, and for pumping water from the artesian well, from which the quarry supply is drawn. In the finishing shop are two rubbing beds, two polishing machines, a planer, lathe, etc., while another building contains electric-driven Scotch circular saws.

The steam boiler plant provides 500 horse-power, for the channeling machines, drills, and for an engine and direct-connected generator, which drive the crane, gang and circular saws, and the machinery in the finishing room.

The plant also includes a blacksmith shop, supply house, stables, and a number of houses built for employees, who number about 140 at the present time.

The Missisquoi Marble Company owns a controlling interest in the Phillipsburg Railway, running from the quarry to Stanbridge, where it connects with the Central Vermont and with the Canadian Pacific System. A branch of the road links the property with its wharf on Lake Missisquoi, whence water communication is uninterrupted to New York City, up the Erie Canal, or by the Richelieu River to St. Lawrence River ports.



Channeled wall in a quarry.

Although the company has been in operation only two years, its product has been widely used. Among the larger buildings in which it figures as interior finish are the Windsor Hotel and the Emanuel Church in Montreal, the Royal Bank in Toronto, the Second National Bank in Cincinnati, St. Jsoeph's Hospital at Victoria, Bank of Commerce, Vancouver, the Post Offices at Vancouver, Regina and Edmonton, and the Hudson County Court House at Jersey City, N. J., Missisquoi marble was used for the exterior of the Workman Building in Montreal.

Mr. F. W. Richardson of Kingston, Ontario is the president of the company, and Mr. Henry Timmis of Montreal is managing director. Mr. Henry Brown is resident manager at Phillipsburg, Mr. S. N. Nickle, quarry superintendent, and Mr. S. G. Timmis, mill superintendent. The courtesies of these officers in furnishing information for this article are acknowledged with thanks.

DIAMOND DRILLING AT TONOPAH

By John M. Fox [1]

(Extracts from an Article in the Mining and Scientific Press)

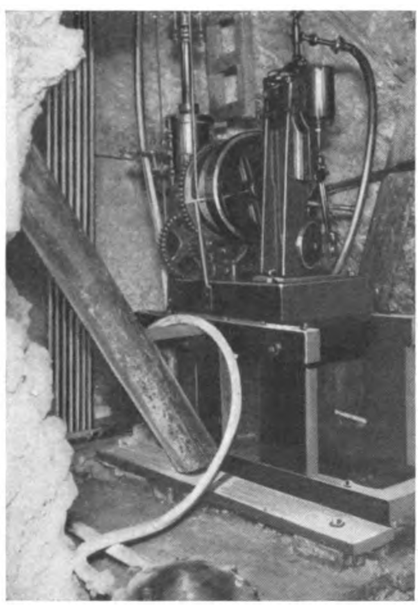
In the autumn of 1908 it was decided to put down a vertical drill-hole from the bottom, or 700-foot level, of the Silver Top mine to gain information regarding the formation through which the Silver Top No. 1 shaft would have to pass if sunk to greater depths. A station and raise were cut close to the shaft and the drill installed. The height of the raise was sufficent to enable the runner to pull in 20 foot lengths. A suitable sump was cut near by for return-water from the hole, thus permitting the use of the same water repeatedly, with the exception of what was lost in the hole.

The drill was a Sullivan Class "C," provided with a hydraulic head and chuck for size "A" rods, capable of drilling to 1500 feet. The engine, drum, and head were mounted in the usual manner, on a standard frame, which was held in place by two heavy sprags wedged to the wall of the station. Compressed air at 90 to 100 pounds pressure was used for motive power, it being tapped from a main-line through a 1-inch connection to the engine. As the level is dry, water for the drill was drawn from the water-pipe line in the shaft. Since a 700-foot head would have provided a higher pressure for the drill than was desirable, a break in the line was made at the 400-foot level. A large sheet-iron tank was installed at that point, and the supply-pipe from above was provided with a valve that was opened and closed automatically by a float. From the tank to the drill approximately 300 feet gave about 123-pound water-pressure, sufficient for the ordinary operation of the feed. In actual running, the hydraulic head was suppled entirely from this source, proving perfectly satisfactory, as it gave clean water at a constant pressure with no entrained air.

[1] Assistant Superintendent Tonopah Mining Co.

The latter is objectionable, giving rise to "jumping" in the rods, with attendant extra wear on the diamonds. As stated above, the water at the bit is used many times. As it flows from the collar of the hole, it is collected in the sump, and from there pumped by a small duplex back through the rods. The supply, of course, has to be replenished from time to time, as some water is lost.

At the start, the hole was reamed to a depth of three feet, and a two-inch inside diameter pipe wedged in it. This projected high enough above the collar to allow the sludge-board to be placed, when actual drilling began. Size "A" rods (standard), having an outside diameter of 1⅝ inches, were used. To these were strung a ten-foot, size "A," plain core-barrel, straight core-shell for "Cossette" core-lifter and size "A" bit. The latter



Sullivan Diamond Drill, Tonopah Mining Co.

has an outside diameter of $1\frac{25}{32}$ inch. With the carbons having a total offset of $\frac{1}{32}$ inch, the diameter of the hole, assuming a perfect bore, would be $1\frac{13}{16}$ inch.

The diamonds or "carbons" used averaged, when new, about $3\frac{1}{2}$ karats each. They were of the best quality, and at the existing market price cost $75 per karat. Six stones were set in each bit, three inside and three out, with a $\frac{1}{64}$-inch offset. The life of a new bit varied greatly in this hole; some drilled 35 to 40 feet before becoming played out, others were retired after drilling only two or three feet. Many causes contributed to this difference in life. Vibration in the rods causes great wear and tear on both stones and metal. Short-fissured ground makes bad drilling, and variable pressure at the feed, which is hard on the bit.

On account of certain conditions obtaining in the case of this particular hole, but one eight-hour shift was employed. The crew consisted of a runner and helper.

As is customary in drilling, no stop was made at the lunch hour, the helper running the machine through that time. The shift went on at 7 A. M. and ceased at 3:30 P. M., unless it was deemed advisable to work through to 5, which was done many times. The runner set the bits after 3:30, and whatever repairs had to be made on the drill or pump were attended to by the helper after that time. All such overtime was credited to the crew on the scale of straight time, being figured to the nearest quarter shift.

With this outline of equipment and labor, we will consider the hole itself. Everything went smoothly till at a depth of 87 feet the character of the formation penetrated changed. The ground became broken, and considerable gouge kept cutting off the water. When solid formation was again reached, the hole was washed as clear as possible and Portland cement mixed with water to the consistence of thick cream, was poured into the hole; 72 hours were required for the cement to become hard enough to drill. Some other soft spots were struck that gave similar trouble, and these were treated in the same way. Thus by cementing and drilling out, the hole was lowered to 225 feet, the last fifteen being in firm ground.

Each morning it was found that the hole was caving worse than the preceding day, and more time was consumed in reaching bottom, the rods often having to be rotated while washing their way down. Finally, at 225 feet, the rods stuck fast; hydraulic and hoist failed to start them, so an improvised jam was made by slipping a 5-foot length of 6-inch pipe over the rods; to the pipe was fastened a rope leading over a sheave, and down. The pipe was snapped up, striking a clamp bolted securely to the rods; the latter were thus released, and when all were out, it was decided to ream to 210 feet, and case with 2-inch inside diameter pipe. This was done in the usual manner, using a reaming-bar, bit, and pilot, and following with casing instead of rods. After the last run was made, the bar, bit, and pilot were removed. A few carbon chips were set in the face of the bottom length of casing, and the latter sent home to its shoulder at 210 feet. The chips provided a means of cutting away slight obstructions that might get in the way while lowering the casing for the last time, They were worthless for any other purpose, and hence were left in the hole. From here on, work progressed without serious trouble, occasional soft streaks being cemented; at 411 feet the water was lost completely; in fact, it ran away so rapidly that the sump was siphoned dry. Sawdust and bran proved ineffectual in plugging the outlet, and until cement was used, the water continued to escape.

Experience gained in cementing sections of this hole may prove of use to others. In the first place, certain brands of cement are more adaptable to this work than others. Those reaching their initial and final set the most rapidly are obviously

the best on account of time saved. The character of the ground being drilled may cause more or less alkalinity in the water. This seems to retard the setting of some cements more than others. In making the mixture it was found that the thicker it was, the better; the limit to which the thickness may be carried depends upon whether the cement is to be poured or not. For comparatively shallow holes, pouring answers very well; for deeper holes, placing thick cement in paper tubes about 12 to 14 inches long, and dropping into the hole, has been tried with success. Three important things to be observed to secure the best results are these: first, get the hole dry, if possible, by blowing; second, tamp the cement frequently while putting it down, which can be done by plugging the end of the rods and giving them a slight drop on the brake (of course, it takes much more time than simply pouring in the cement and allowing it to set, but the results are more certain, and, in the long run, time will almost always be saved); third, if a brand of cement prove unsatisfactory, try others. One can probably be found to do the work.

Vibration of the rods, which is mentioned above, can be greatly reduced, if not eliminated, by coating them with crude petroleum when lowering. This provides a lubricant that clings in spite of the scour of water and sludge. [Special "rod grease" is obtainable from the drill manufacturers. Ed.]

Assays: Sludge samples were taken from every run and assayed. Core samples were taken from time to time as a check, or wherever it was thought necessary, by reason of the appearance of the core. It was realized that sludge-samples are only indicative of the presence or absence of valuable material when drilling under such conditions as the above. No reliability can be placed upon them quantitatively for many reasons: for example, a high-grade streak of narrow width would salt a ten-foot run. If one succeeded in coring the streak and its adjacent walls, reliable information would have been gained in regard to where the valuable material came from, but without such proof, no certainty could be felt as to whether the ore were ten feet wide, and low in value, or one or two inches wide, and high in grade.

NOTES ON DRAINAGE TUNNELS IN PENNSYLVANIA

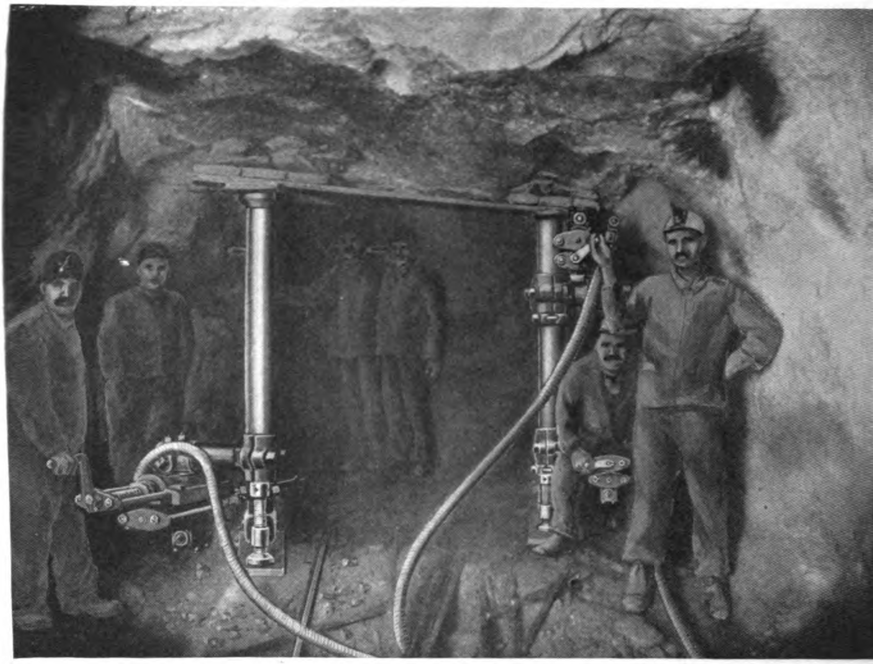
Contributed

The problem of mine water and its disposition is by no means confined to the western gold and silver camps. While the tunnels at Cripple Creek have achieved much notoriety, the fact should be noted that in the anthracite coal fields of Pennsylvania the last few years have seen some elaborate underground drainage systems established. While the Colorado tunnels have been driven with the idea of use as haulage ways and, in some cases, for mining ore deposits, those in Pennsylvania are water carriers only. Their construction is justified by the saving they occasion in pumping costs, and by the exposing for operation of low level coal seams.

Among these tunnels may be mentioned that on the property of G. B. Markle and Pardee Bros. & Co., draining the Lattimer and Jeddo basins, comprising about five square miles of territory in Luzerne County. This tunnel is about three miles long; and the Quakake tunnel, 4,500 feet in length, which drains the south basin of Beaver Meadow, on the property of Coxe Bros. & Co., Inc., near Weatherly, in Carbon County.

These are older tunnels. The Lehigh Coal and Navigation Co. has under construction two new drainage systems which are of even greater interest than those mentioned.

One of these, the Lausanne or Mauch Chunk tunnel, near Mauch Chunk, Pa., was described in "Mine & Quarry" for



Sullivan Rock Drills in the Mauch Chunk Drainage Tunnel.

June, 1909. It is about 7,500 feet long and constitutes the outlet to the Lehigh River for what is known as the Buck Mountain gangway, a series of passages about 13 miles in extent, now being driven to drain fourteen different collieries in the Panther Creek basin, between Mauch Chunk and Tamaqua.

The tunnel was driven by the Portland Contracting Co., of Pottsville, Pa., who set a record, for this region, of 349 feet of single heading advance during one month on this enterprise. Sullivan "UH" 3⅝-inch drills were used.

The same contractors have also finished (in December, 1909) a tunnel 4,935 feet long at Oneida, in Schuylkill County. This waterway is doing the work of five large pumps at the mine owned by Coxe Bros. & Co., Inc., and operated by the Lehigh Valley Coal Company.

The water passes through the Tomhickon Valley by way of the Catawissa and Susquehanna Rivers. The tunnel has been driven through solid rock, consisting of hard conglomerate, close-grained blue stone, and red shale, in about equal portions, all fairly hard drilling. The inside or mine heading was begun in May, 1908, and the outside end in August, of that year. The working face is 7 x 11 feet, with a ditch at one side 2 x 1½ feet.

After August, the tunnel was driven with Sullivan "UH-2" drills, of which two were used in each heading. In the conglomerate, however, three drills were used. The two headings together averaged 350 feet per month, working one shift. In July, 1909, the two headings were driven 408 feet; in August, 419 feet and in September 410 feet.

An average of 18 holes were drilled in each face, to a depth of about 7½ feet. When fired with about 140 pounds of 60 per cent dynamite, an average "pull"

or advance of seven feet was gained. About 705 rounds or faces were drilled to drive the 4,935 feet of tunnel. The average drilling time per round was 7 hours. From the above figures about 67 feet of hole were put in per drill per seven hours' work.

Each face has 8.9 square yards, so that 20.74 cubic yards of rock was removed by 135 feet of holes, or, a cubic yard was removed by 6.4 feet of drilling.

The contractors have used Sullivan "UH-2" (3⅝-inch) drills in much of their shaft and tunnel work, and have on record some unusually low maintenance costs for these machines on this and other jobs.

PROBLEMS AND METHODS ON A BARGE CANAL CONTRACT

By Wm. M. McKearin[1]

The present Erie canal is the result of what was generally considered in 1817, a visionary dream. It has so well proven its value as a connecting waterway between the Great Lakes, Lake Champlain, and The St. Lawrence with the Atlantic ocean at New York via The Hudson River from Troy, that to-day improvements to the amount of $10,000,000 have been authorized and are now in progress. These improvements will consist of widening and deepening the canal, and in some places changing its course, in order to utilize various rivers and lakes. When this has been completed, it will be possible to deliver lake cargoes at the seaboard in the original vessels, without transferring at Lockport, as at present. Then, too, steam tugs will be used for the most part in place of mules. This will make it possible to handle a great increase of traffic.

Contract No. 40 consists of widening the canal from 70 to 100 feet, deepening it from nine to 20 feet, and building culvert entrances, guard gate, stream entrances, bridges, etcetera, from Lockport locks to Sulphur Springs guard lock, a distance of about five miles.

The canal descends over a cliff at Lockport about 50 feet high, known in geology as the Niagara escapement. This consists of drab colored limestone overlying gray limestone, which in turn overlies shale. The top layer of limestone is soft and filled with pockets of crystals. The gray limestone is more compact and a trifle harder. Occasionally some flint is met with, rendering channeling and drilling difficult; otherwise all three formations are easily worked.

[1] Farmers' Bank Bldg., Pittsburg, Pa.

This contract represents $2,166,000 worth of work and was awarded to the United Engineering & Contracting Co., of New York City, in December, 1908. This company in turn sub-let to the Rochester Construction Co., of Rochester, N. Y., the part known as the Canal Quarry C .'s section, and to Bellew & Merritt, of Tuckhoe, N. Y., the berm and harbor sections. The sections sub-let cover a distance of about one mile.

HARBOR SECTION

Following the canal west from Lockport, the harbor section of Bellew & Merritt is first encountered. Steam drills are used to drive holes about 14 feet deep. The steels are sharpened with an "X" bit of 2½-inch gauge for the starters and ¼-inch decrease in gauge for each successive length. The wear is very slight and often a steel is used a full week before going back to the blacksmith. A Sullivan "Y" channeler with boiler is making the wall cuts. The channeling is started one foot above the water line. On the south side of the canal the channeling consists of two cuts each about 10 feet deep. On the north side, one 11-foot cut is being channeled from the present bottom of the canal, which will bring it level with the south side.

Four Sullivan channelers on the north wall.

All the rock in the new portion of the canal will be drilled and shot out in two benches. The remainder, beneath the old canal bed, will be worked in one bench. The spoil is loaded into cars by a 75-ton steam shovel. These cars are hauled by two dinkey locomotives to a dump about a quarter of a mile away.

Where the channeling was first started, a high, loose bank crowded the stone which was to be cut. Not only this but the rock itself was very much broken up. For these reasons the "Z" solid bit was used.

It has given the best of satisfaction and an average of 86 square feet per eight-hour shift was made. In one shift, 156 feet were channeled and in one forenoon of four hours, 85 feet. The channel was kept free of mud while the steels were being changed, by a steam siphon, made on the job, and connected to the boiler on the channeler.

BERM SECTION

Next in order is the "berm" section, worked by the same contractor. Here also a Sullivan "Y" channeler is in operation. A bench about 16 to 18 feet in height and 36 feet wide is being worked by steam drills. This is removed before the level for channeling is reached. The holes are inclined on a slight angle and placed about six feet apart. Four to six sticks of 50 per cent dynamite are used to spring each of the holes, after which a charge of ten sticks is used for firing. As soon as the rock is shot out, a steam shovel loads it into skips, handled by two locomotive cranes. The cranes place the rock on the spoil bank, about 75 feet back from the prism.

The next section is that of the Rochester Construction Co. A bench similar to the one mentioned, is being removed here by air drills. For quick mudding of the holes before loading, a long one-inch iron pipe is connected to the air line by a hose. It is then lowered to the bottom of the hole and by turning the air on suddenly, the mud is sent flying into the air sometimes as much as 10 or 15 feet. Here the holes were not sprung, but 12 to 14 sticks of powder were used in each for shooting. The spoil is handled rapidly by means of a large steel tipple, mounted on trucks and tipped at a slight angle. There are two tracks running the length

of the framework and on each track is a car with a capacity of six yards. These cars are hauled to the rear end of the track by means of a wire cable and dumped. The entire mechanism is operated by a 100 H. P. motor. The cars are loaded by a 75-ton steam shovel and can make a trip, including loading and dumping, in less than three minutes.

CHANNELING WORK

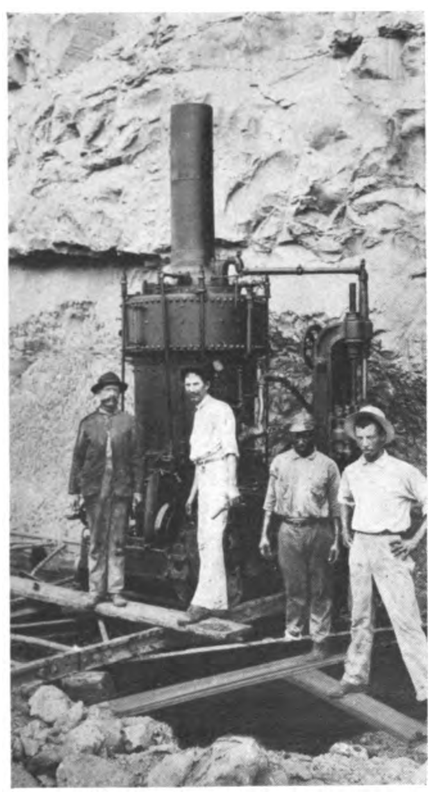
The Sullivan "Y" channelers with boilers are in use here. Three piece gang steels are used to good advantage. Each bit is 1 x 2¼ inches in size. The gauge of the starters is three inches with a drop of ⅛-inch for each successive length. Owing to the seepage from the canal, the mudding of channels was very difficult until two 3-inch suction diaphragm pumps were procured, and they relieved all the trouble. An average of 90 square feet per eight-hour shift was channeled here during the first two weeks of operation. The best work for one shift was 125 feet.

The work being done by the United Engineering & Construction Co. lies adjoining this section on the west. Rock is being excavated at three points, and earth at about three others. At the first opening, two Sullivan "Y-8" channelers with boilers were put to work. Where channeling was first started the rock was not only very uneven but also very loose and broken up as a result of the blasts. However, the three piece gang was used and fully proved its equality to, if not superiority over the "Z" bit under these conditions. The presence of quantities of flinty spar made progress slow. The channeling was handicapped not only by the conditions mentioned, but by the fact that nearly every cut was started under water, which covered the cut in many places as much as 18 inches.

In spite of the nature of the rock, the channeled wall is solid and straight, and will not be a future source of repair expense. The photograph on page 394 shows this north wall, and the difference between the old blasted wall on top, and the channeled cut below is a powerful argument for the modern method. At this point the canal is down to grade, and the picture shows the excavation completed for about one-half its width.

In order to handle the large volume of water, two electric centrifugal pumps and two air-driven plunger pumps, with a combined capacity of 4,000 gallons per minute were installed, and these were later supplemented by a dam, shown in the picture just behind the steam shovel, and another pump.

The photograph on page 392 shows four Sullivan "Y-8" channelers in the old canal bed, cutting the north wall ahead of the shovel shown on page 394. In the



A Sullivan channeler at Gatun, Isthmus of Panama.

North wall, showing old, blasted, side of canal above, and channeled cut below.

background a gang of 10 Sullivan drills is at work on the bench. The cost of channeling here was increased by the irregularity of the old canal wall, which frequently projected out beyond the surveyors' line, and had to be laboriously trimmed off before the channelers could be put to work. Some idea of the hardness of the rock may be formed from the fact that only about 12 lineal feet of channel per machine could be carried down to grade with success, and even then it was sometimes necessary to use three sets of cutting bits to channel 18 inches, the length of the feed. The channelers are boarded in to give the runners some warmth from the boiler, and protection from the weather.

At the various rock openings, 30 Sullivan "UF" (3¼-inch) air tappet valve drills are in use. While the water remained in the canal the rock was shot out in two benches of about eight feet each but now it is worked in one.

At one opening the spoil is handled by a guy derrick, operated by an air-driven hoist. At another opening, which was directly under a high tension electric line, it required three small air-driven hoists, one stiff leg derrick, and one guy derrick and a car to dispose of the spoil.

POWER PLANT

In the central power house of the United Engineering & Construction Company are installed three 32 x 20 x 30 inch duplex air compressors, each direct connected to a 500 H. P. synchronous motor. The combined capacity of the compressors is 8,400 cubic feet of free air per minute. The air is discharged into after-coolers, from which it goes to two large receivers. From here it is piped throughout the job, a distance of five miles. One of the striking features in the compressor room is the scheme for economizing oil. All oil used, except that in the cylinders, is drained to individual reservoirs in the floor, to the rear of each machine. From these reservoirs it is blown intermittently by compressed air to the filter. On a test run of 20 days, one barrel of 52 gallons

Cantilever excavator at work.

supplied a consumption of 280 gallons, that is, was used 5.38 times Not content with this tremendous saving, the oil entrained with the air and gathered with condensed moisture on the bottom of the after-coolers, is blown into a large barrel from which it is taken to be used on steam shovels, chains, etc.

The master mechanic and assistant have an office here and the electrician a work room. A blacksmith shop near by is equipped with four up-to-date forges, and the machine shop is furnished with lathe, planer, drill press, etc. The store house, stable, and a camp for the mechanics are also located here. The superintendent also has an office building on the grounds.

SPOIL REMOVAL

Just west of this plant, an ærial cableway of 75 and 100-foot towers has been erected. The skips are of six yards capacity, loaded by two 75-ton steam shovels. Another similar shovel loads the skips for a 100-foot double boom crane. Continuing westward we meet the most striking sight on the contract. (See cut above.) This is a steel bridge-like affair, mounted on large trucks and tipped at a slight angle. The lower end reaches to the edge of the canal and its length is 395 feet. It has a large skip, with a capacity of about four yards, which travels 374 feet. This skip will go to the lower end, load, travel to the high end, and dump the dirt on the spoil bank at a rate of fifty trips per hour. It is operated by a 225 H. P. motor and is known as a cantilever. Two dirt drags and a steam shovel are in use near by for dirt excavating.

At Sulphur Springs, the extreme western end of contract No. 40, two Sullivan "Y-8" channelers, another cable tower, and steam shovel are in operation. Throughout the contract, 5,000-candle power flaming arc lamps are in use. Six 6-inch pumps, direct connected to 25 H. P. motors, which have a capacity of 1,000 gallons each per minute, are used to keep the refuse water out of the prism. In the shovel pits, six four-inch air-driven pumps are employed for the same purpose.

Work upon contract No. 40, described above, began last fall and has been pushed as rapidly as possible, during the winter months, when the canal is not in use. By May 15th it must again be open for

the passage of vessels, so that much of of the work must be suspended during the summer. At the close of navigation in the coming autumn, with all equipment on the ground, and many operating problems solved, the contractors will be prepared to prosecute their undertaking to much better purpose. It is estimated that about two years' work remains to be done.

COST ANALYSIS OF STONE CONSUMPTION IN UNDERGROUND DIAMOND DRILLING

By Benjamin H. Case[1]

The cost of carbons and borts consumed in boring 39 underground holes at the Burra Burra and London mines, Ducktown, Tenn., is shown in the table accompanying this article. The holes were drilled in 1907, with two Sullivan machines of the "S" type, and all but three holes, aggregating 284 feet, were horizontal across the formation. The core was 15/16 inch diameter, and the holes 1½ inches diameter.

The highest cost per foot was $3.66, in a horizontal hole started in the footwall, and drilled to a depth of only 8 feet, consuming 1 61/64 k. of $15 borts. Excepting this hole, which penetrated very hard quartz, the highest cost for a hole drilled with borts was $0.8338 per foot. This hole was drilled in the footwall of the Burra Burra mine to a depth of 52 feet, 37 feet being in hard silicious vein material and 15 feet in country rock; 2 57/64 k. of $15 borts were consumed in boring it.

The lowest cost per foot was $0.0321, and was obtained from a horizontal hole bored to a depth of 190 feet in the hangingwall of the Burra Burra mine. This hole penetrated 10 feet of vein material at its mouth, and the remainder cut through soft mica schist so thinly foliated that there were but few pieces of core recovered more than ½ inch thick. The stone consumption was only 39/64 k. of $10 borts.

COST USING CARBONS

The highest cost of a hole drilled with

ANALYSIS OF STONE CONSUMPTION

Feet Drilled			Stones Consumed	Cost per Carat	Total Cost	Consumed per Foot	Cost per Foot
Total	Vein	Country					
1437	411	1026	25 55/64 k.	Borts at $10........	$258.60	1.151/64 k.	$0.18
546	65	481	16 17/64 k.	Borts, 7 13/64 @ $10..... Borts, 9 4/64 @ $15.....	72.03 135.94	1.304/64 k.	0.3809
798	226	572	14 45/64 k.	Borts at $15........	220.55	1.179/64 k.	0.2764
167	90	77	8 32/64 k.	Borts, 6 42/64 @ $15..... Carbons, 1 52/64 @ $85 ..	99.84 154.06	3.246/64 k.	0.9225
840	228	612	5 2/64 k.	Carbons at $85......	427.66	0.383/64 k.	0.5090
3788	1020	2768	70 4/64 k.	Totals and averages	$1368.68	1.184/64 k.	$0.3613

[1] Mining and civil engineer, 63 Atkin Street, Asheville, N. C.

carbons was $1.155 per foot. This hole was drilled in the footwall of the London mine to a depth of 92 feet, and penetrated 22 feet of vein and 70 feet of country rock. The loss in stones was 1¼ k. at $85. The lowest cost with carbons was $0.0718 per foot, from a hole in the footwall of the London mine which penetrated 30 feet of vein, and 44 feet of country rock. The stone consumption for the hole was 1/16 k. at $85.

COST USING BORTS

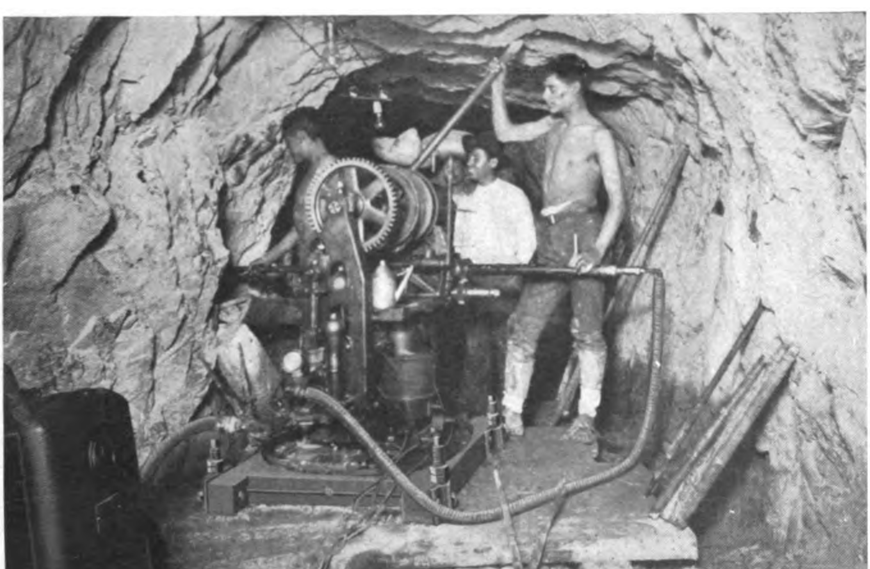
The stone consumption given in the table does not take into account the loss from scrap borts in the drilling. This loss was: 4 58/64 k. at $15, $73.59; 5 57/64 k. at $10, $58.90; total 10 51/64 k., $132.49. The above amount distributed to the 2,948 feet drilled wholly and in part with borts gives an additional cost of about 4½c. per foot for holes drilled with these stones. There was no loss in carbon scrap, this loss occurring usually when the stones have worn too small to be utilized in a bit.

Summarizing, and leaving out of the calculations those holes where both borts and carbons were used, the costs with borts were for 2,781 feet drilled, $687.12, or the cost per foot, $0.247. The additional loss for scrap, which amounted to $0.045 per foot, brings the cost up to $0.292 per foot. This is considerably less than the carbon cost of $0.5090, given in the table.

ADAPTABILITY OF EACH STONE

Borts may be profitably used in drilling soft ground, but in hard material they are useless, as the stones, all of which contain flaws, will shatter when encountering hard rock. It is doubtful if borts could have been used with cheaper results in drilling the 840 feet that were drilled with carbons. Some of this ground they would not have cut without great waste. Where part carbon and part borts were used, the carbons were substituted for the borts when it was found that the borts would not stand the work.

In some formations, where there are strata or zones of varying degrees of hardness, bits set with carbons might alternately be used with those set with borts, but the bits could not very well be set in advance owing to the varying gage of the hole.—*Engineering and Mining Journal.*



MINE AND QVARRY

VOL. V. No. 1 JULY, 1910

SULLIVAN CHANNELERS QUARRYING BLOCKS 20 FEET THICK IN INDIANA LIMESTONE

INDIANA OÖLITIC LIMESTONE

A TENNESSEE COAL MINE

A PORTABLE DRILLING OUTFIT

PVBLISHED BY THE SVLLIVAN MACHINERY CO. 150 MICHIGAN AVE., CHICAGO.

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MINE AND QUARRY

Vol. V, No. 1 JULY, 1910

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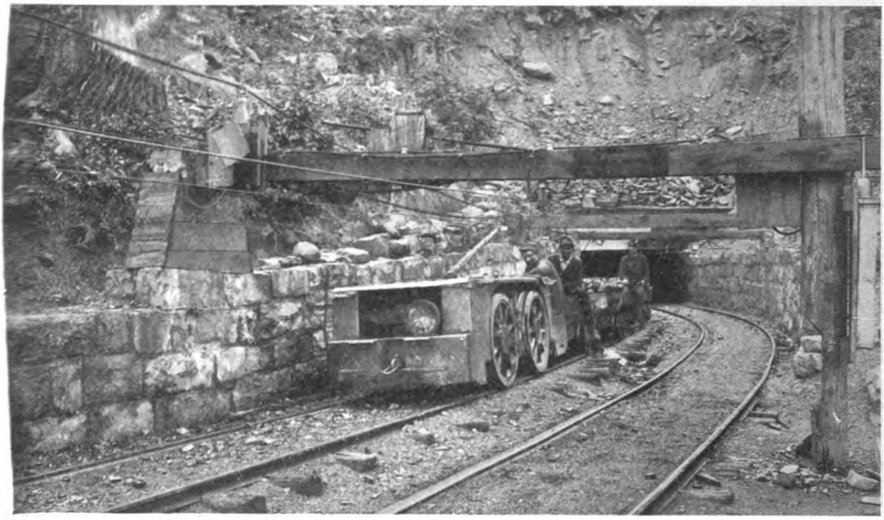
PERMANENT VALUE OF DIAMOND DRILL CORES

Dr. Malcolm Maclaren, who has recently conducted a geological survey of mines in the western Australia goldfields, some months ago called the attention of mine owners to the value of diamond drill cores as permanent records, in the following letter to the Kalgoorlie Chamber of Mines: "During the course of my present geological examination of the Kalgoorlie field, I have been forcibly impressed with the great geological value of bore-cores, and also with the remarkably small proportion of the many miles drilled now available for reference. Much time would have been saved in the progress of my work, and many inferences, now lacking confirmation, would have been proved or disproved had cores been generally preserved. It appears to have been the practice in the past to throw away the cores after mere inspection had indicated a lack of values. The present practice of using the whole of the core for assay is also responsible for the disappearance of many cores. In either case valuable information may have been lost. I have therefore to suggest that, in addition to the information usually contained in core-books, as much as possible of all cores be preserved, since it is easily conceivable that future development may render the re-examination of any given core highly desirable. This end may be attained, and a portion at the same time be made available for assay by splitting the cores longitudinally by hand, or, preferably, by a simple rock-splitting machine, such as may be designed and made on any mine. The cores themselves may be simply, cheaply and efficaciously packed in ordinary dynamite boxes, a definite order of deposition in these being adopted. Longitudinal divisions are unnecessary, but horizontal separation is desirable. Inasmuch as several cores now available are valueless on account of the obliteration or disappearance of the paper labels generally used, it is suggested that the number of the bore, and at more frequent and suitable intervals, the footage be painted (before transference from the large core trays) on the cores themselves. An excellent and simply made indelible and waterproof paint for this purpose may be made by dissolving sufficient 'Bank of England' sealing-wax in methylated spirit to form a viscous fluid. The expense of painting and boxing is trifling, and cores thus boxed occupy the minimum of storage space."

The practice of retaining diamond drill cores and analyzing their significance is generally followed in the Lake Superior iron and copper region and in many other American mining districts; and the studies of Prof. A. C. Lane, while state geologist of Michigan[1], and other engineers have demonstrated how far the results of drilling may be utilized; but there are still numerous instances in which the cores are not preserved or the most made out of their indications. The above letter may contain value for managers who have not thought of this matter as an important one.

[1]See MINE AND QUARRY for January, 1910, p. 372.



The mouth of the mine, Wind Rock Coal & Coke Co.

A TENNESSEE COAL MINE

By W. S. Hutchison[1]

The Wind Rock Coal & Coke Co.'s No. 1 mine is located at Wind Rock, Anderson County, Tenn., about four and one-half miles north of Oliver Springs. It lies in the southern edge of the Wartburg Basin, at an elevation of 2,400 feet above the sea level. This location commands a splendid outlook over the valley to the south. The camp can be reached from Khotan, on the Louisville and Nashville, or from Oliver Springs, on the Southern Railroad.

The mine was opened in the early part of 1904 by the Wind Rock Coal & Coke Co., composed of Knoxville parties. Development was delayed by encountering a split, composed of hard fireclay, which has since been exploited and found to be confined to 200 acres. The split is of a peculiar formation, being lenticular in shape, with its major axis approximately parallel to Walden's Ridge. The extent of the split was ascertained by driving a pair of entries through on the bottom bench of coal, and its maximum thickness was found to be 35 feet. Further exploiting was carried on by skirting the edge of the split and by outcrop prospecting. In 1905 the mine was purchased by the Bessemer Coal, Iron & Land Co., of Birmingham, Alabama, which now operates the property, consisting of 4,000 acres, as measured within the 30-foot crop line.

GEOLOGY

The seam of coal operated probably belongs to the lower Kanawha measures and is known as the Dean Seam. It lies high in the mountains and extends throughout the Wartburg Basin, having extensive workable areas in Campbell, Anderson, Morgan and Scott counties in Tennessee, and also in Bell County, Kentucky.

The inclination of the seam is from one to two per cent to the northwest. The main entry of the mine runs in practically the same direction, necessitating a grade against the load. This is unavoidable,

[1] Knoxville, Tenn.

the location of the railroad rendering this arrangement necessary. The thickness of the coal in the mine proper averages four feet, nine inches. The coal has an exceptionally good top of solid blue slate from 15 to 30 inches in thickness, and is underlaid by a massive sandstone formation. At certain points in the mine a soft, white fireclay, which lies just below the bottom, causes trouble and expense by heaving the floor and thus increasing its pressure on the pillars. This condition seems to be unavoidable.

The analysis of the coal is as follows:

	Per cent
Moisture	1.90
Volatile matter	38.00
Fixed carbon	56.64
Ash	3.46

Sulphur (taken separately, 0.59 per cent).

It is an excellent steam fuel and the entire output is readily disposed of to railroads in the states of Georgia and Florida.

MINING SYSTEM

The mine is developed on the room and pillar system, as indicated by the plan on this page. The main entry and air courses are driven almost due northwest. On the first face or main entry, all butt entries were turned off at right angles to the main entry, but considerable trouble was experienced from hill seams in the top, causing bad top in the butt entries.

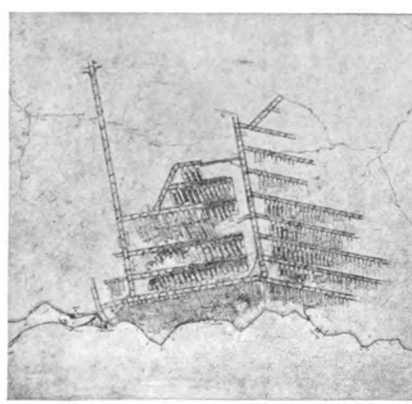
Later this trouble was successfully avoided by turning all butt entries obliquely from the face entries. On entries next to the outcrop, the rooms and pillars are each 21 feet wide, the necks being 21 feet long by ten feet wide. On all other entries, the rooms are driven 30 feet wide with 25-foot pillars, and room necks ten to 12 feet wide and 21 feet long. In all cases, 150 to 250 feet of solid coal (depending on the amount of cover) is left on each side of the main entries before the first rooms are turned on the various butt entries.

The rooms, except as noted above, are driven 215 feet deep, leaving 20-foot barriers between the faces of the rooms, when driven up, and the air course beyond. The pillars are at once robbed back to a point about 65 feet from the entry rib. These butt entries are driven on 40-foot centers, leaving a chain pillar on the lower side of the air course. About 75 per cent of these pillars are cut with machines of the Sullivan type, the remainder of the coal being won with hand picks, for the sake of safety.

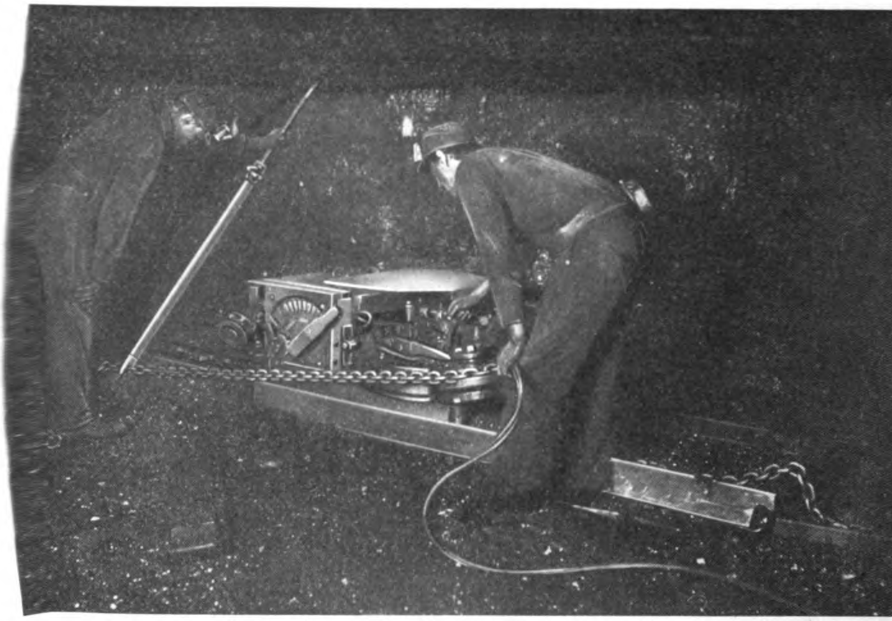
An original modification of mining on a retreating block system is now being tried. Narrow rooms are driven in pairs on butt entries on 175 foot centers. When the rooms are driven up, the ribs are undercut by machine as long as it is safe to do so, after which the remainder is cut by hand. The track is advanced after each cut to facilitate loading. The advantage gained lies in the long faces, which are worked quickly and effect a saving of time by concentrating labor, equipment, etc. The top is carried on timbers until the coal is removed, and retreat is made behind a new block.

UNDERMINING

The output is at present about 1,000 tons per day of nine hours. The coal is all undercut before it is shot, 70 per cent of the total being mined by Sullivan con-



Plan of mine workings.



Sullivan machine half way through the sumping cut.

Sullivan machine crossing a room face under its own power.

tinuous cutting electric chain machines, and the remainder by hand and by two chain breast machines. The Sullivan machines are of the low vein "CE-6" pattern, four cutting to a depth of six feet, three inches, and the fifth, five feet, three inches. They make a kerf, or mining, five inches high. They are used largely for cutting the long panel faces or pillars, where their continuous cutting principle of operation renders them unusually rapid and economical. They are also employed in driving up rooms, and in narrow work in the vicinity of the machines. The average rate of cutting is seven to eight 30-foot rooms per shift of nine hours, each machine furnishing coal for 20 to 25 loaders. One runner has recently cut eight rooms of the above width, and three narrow places, in one shift.

It is found that the best results are obtained by cutting two to three inches above the bottom. Due to the friable character of the coal, the bottom coal is shattered so that it can readily be shoveled up from the natural bottom of the place undercut.

The cost of undercutting the coal, with the Sullivan machines, is 3½ cents per ton, run of mine, for room work, with a bonus of 30 cents per place for narrow work. On pillar work and on all cuts, 60 feet long and over, the cost per ton is three cents, run of mine. These costs, of course, include both the machine runner and helper. Twenty-two cents per ton is paid for loading coal over four feet in height, with ten per cent added when the coal is under four feet. This last named price includes shooting, loading, and timbering. In shooting 30-foot rooms, 12 to 14 inches of powder are used in each rib, and in shooting entries, about the same amount of powder is required. The average cost for powder per ton of coal mined, is from three-quarters of a cent to one cent. This low powder cost is due to the fact that undercutting causes the coal to fall readily.

The undercutting is done entirely on the night shift, except the narrow work, which is double shifted; and the coal is loaded out during the day time. This prevents delay to the mining machines in moving from place to place, by locomotives or car blockades. It also permits the use of a smaller power plant than would be possible if the undercutting and hauling loads were incurred at the same time.

LOADING MACHINE

A coal loading machine for use at the face, one of the first built, is an interesting feature of the underground equipment. This apparatus is practically a dirigible shovel, mounted on a self-propelling truck, which carries also a front and rear endless conveyor. The latter is also dirigible through about 11 feet of arc. The shovel is designed to work in a seam four and one-half feet or more in thickness. It has a capacity of 250 pounds per stroke and makes from 18 to 20 strokes per minute, the machine cleaning up the room from two tracks, one in each rib. Electricity, gasoline, air, or steam, can be used for power. Four electric gathering locomotives, one electric tram locomotive, two reserve locomotives and two mine pumps complete the mine equipment.

HAULAGE

The "pull and change" method is used for handling loaded and empty cars. The cars in the rooms are trammed by the miners and are brought to the mouth of the butt entry by a gathering locomotive. The tram locomotive coming in, switches its empty cars to the gathering motor and picks up the loaded cars. No side tracks are used.

Changing cars is usually accomplished in the following manner: the tram motor, pulling an empty trip in, deposits its empty cars on a cleared butt-entry track, then goes forward to the adjacent entries and picks up a load, while a gathering locomotive distributes the empties.

Sullivan machine moving on power truck.

When a cleared butt entry is not to be had, the tram locomotive makes a flying switch of its empties to the main entry and switches itself onto a loaded butt-entry track. The empties are then delivered to the various rooms, as required, by the gathering motors, while the tram motor takes its load to the outside. When the grade permits, the tram motor comes in ahead of its empties, gathers its loads as it advances along the entry, and pushes them ahead, distributing the empties as it goes and then returning with the loads. These methods of course necessitate a large supply of mine cars, some 300 being in use.

Two and one-half per cent is the steepest grade against the loads on the face hauls. The butt entries are very undulating, with a maximum grade of 13½ per cent. This, however, is in favor of the load. Wrecks formerly were frequent on the butt entries, but this trouble has been partially eliminated by replacing the 20-pound rails, then used, by 35-pound and maintaining an excellent haulway.

On reaching the surface, the cars are hauled over the weighing scales to the tip house. Here the coal is dumped into ten-ton monitors, which run by gravity over a standard gauge inclined plane, 4,350 feet long, to the lower tip house, where the coal is again dumped into railroad cars and weighed for shipment. The monitors have a carrying capacity of ten tons each, and are run double or in tandem, i. e., each trip carries a net load of 20 tons to the lower tip house.

The total length of the incline is 4,350 feet, with a vertical difference in elevation between the top and bottom of 1,300 feet. The average grade of the incline is 32 per cent, the maximum being 54 per cent. The average time required to run a trip over the incline is three and one-half minutes.

The haulage drums are set vertically in tandem, the front drum being eight feet in diameter and the rear drum, nine feet. The former has four grooves and the latter five. The drums are provided with differential groove rings and with 10 inches of brake surface on both sides of each drum. The drums are governed with a hand brake, operated by a man in the tip house. The rope used is 1⅜ inch plow steel, "lang lay."

Incline and upper tip house.

VENTILATION

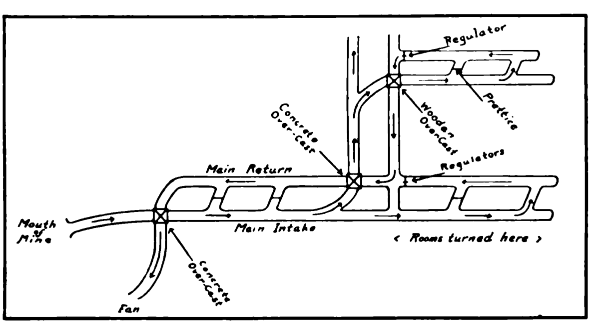
Ventilation is accomplished by means of the split system. There are eleven splits in use at the present time (see sketch on this page). For butt entries, which are driven 1,800 feet as the standard length off the butt panels, wooden overcasts are used. These overcasts are built of 6 x 8-inch framing, boarded on both sides with one-inch plank and tamped with clay. For permanent overcasts, quarried sandstone laid in Portland cement, is used.

For brattices on butt entries, 6 x 8-inch framing is employed, boarded on both sides with one-inch plank and filled with clay. On all face entries and main airways sandstone and Portland cement brattices are used, 18 inches thick, with a buttress on each side, having a base of 3¼ to 4 feet. The buttresses are used for stiffening where the brattices are over 5 feet in height. The regulators are ordinary wood brattices, with a slide door device which can be locked for any required opening.

The fan is of the disk type, belt driven by an electric motor, and runs exhausting. It displaces 50,000 cubic feet of air running at 310 revolutions per minute against a ¾-inch water gauge.

SURFACE PLANT

The power house is located 250 feet from the pit opening. Direct current



Sketch of ventilation system, Wind Rock Mine.

at 250 volts, is furnished by two units, one a 150 K.W. engine generator, direct connected, for the machine load on the night shift; the other a 200 K.W. engine generator, direct connected, used for the day load.

A boiler room, equipped with two 150 H. P. high pressure, water tube boilers, adjoins the power house. Coal for the boilers is hoisted from the outside tram road level to the boiler room by means of a small steam hoist.

The water supply is obtained from three small mountain streams which empty into a reservoir, constructed in a convenient hollow in the mountain side. The retaining wall is 35 feet in height and has a fifteen-foot base, channeled two feet deep out of solid rock. The wall has a batter of 3⅛ inches to the foot, giving it a crest nearly five feet wide.

The reservoir pumping plant consists of a 5 x 8-inch, triplex, electrically driven pump, which raises water through a two-inch discharge line to a vertical height of 400 feet and empties into a 16,000 gallon tank. It is rain and surface water, well suited for boiler use and causing little or no corrosion or scale. It is interesting to note that the reservoir has been well stocked by the government with black bass, by way of furnishing diversion for the company men during a scarcity of orders.

A well equipped machine and blacksmith shop, motor barn, fan, oil and tip house and saw mill comprise the rest of the surface buildings and equipment.

The writer is indebted to Mr. C. H. Thompson, General Manager of the above company, for data used in the preparation of this article, and to Messrs. Doyle, mine foreman, and Scarborough, night foreman, for assistance in securing photographs.

DIAMOND VERSUS "SHOT" DRILLS IN NOVA SCOTIA

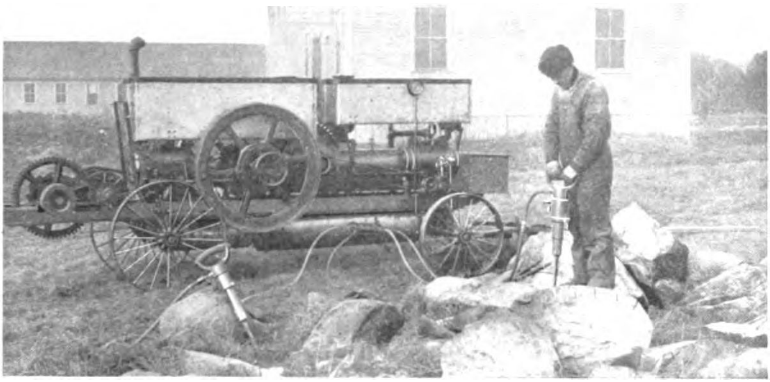
The report of the Department of Mines of Nova Scotia for the twelve months ending September 30, 1909, has just been published. On page 179 and following, will be found the report of Hiram Donkin, Deputy Commissioner in charge of Government prospecting drills. The Government of Nova Scotia is the only user of drills, so far as available information shows, which employs both core drills of the shot or calyx type, and diamond drills in the same formation. The following table from the report, shows the comparative cost of drilling with the calyx and diamond drills·

	1908	1909
" Cost a foot for all boring	$1.06	$1.405
Cost a foot for all boring by diamond drills	0.845	0.79
Cost a foot for all boring by calyx drills	1.34	2.166
Shot-cost a foot for all boring by calyx drills	0.056	0.055
Carbon-cost a foot for all boring by diamond drills	0.077	0.037"

Total boring for diamonddrills	3.378 feet
Total boring for calyx drills	2,198 feet
Average drilling per shift of ten hours, diamond drill	13 feet
Average drilling per shift of ten hours, calyx drill	6 feet
Cost of labor and management per foot, diamond drill	$0.58
Cost of labor and management per foot, calyx drill	1.17

From the above tables, it will be seen that in addition to the economy in carbon wear over shot wear, in using diamond drills, the economy of labor and management per foot, and in drilling speed is very noteworthy.

The formations encountered were the same in each case. Practically all of the drilling was done for coal, and the formations penetrated were principally shales, sandstones of moderate hardness, some limestone, and in one hole, bored with the diamond drill, the presence of conglomerate brought the cost above the average.



Sullivan "WK-3" compressor and Sullivan hammer drills, breaking up boulders.

A PORTABLE DRILLING OUTFIT FOR STREET WORK AND LIGHT CONTRACT EXCAVATION

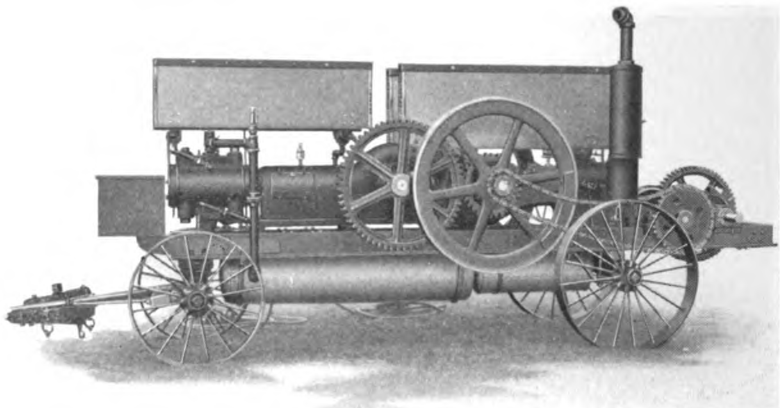
By Samuel Seaver[1]

The City of Gloucester, Mass., located on the southeast end of Cape Ann, is for the most part, built on a solid granite formation. Large areas are covered with boulders, deposited during the glacial period. Many of these boulders are ten feet or more in diameter, and some even as large as twenty feet through. These conditions have rendered the building of streets and laying of water mains difficult and costly; solid rock, or ground filled with these large boulders, being constantly encountered.

Until recently, the City of Gloucester has carried on this work by hand drilling, and later by means of steam tripod drills of the Sullivan UB pattern, operated by portable boilers. Both methods, however, have been found expensive and slow. After studying the conditions thoroughly, the present street commissioners decided that the work could be done more rapidly and at lower cost if compressed air were available.

Accordingly, in March of this year, they purchased an outfit, consisting of a Sullivan air compressor geared to a gasoline engine, and the whole mounted on wheels. The compressor operates two hammer drills, of the Sullivan Class DB-15 and DB-19 types respectively. The first of these drills puts in holes up to three feet in depth, and weighs 20 pounds. The size DB-19 puts in holes five feet in depth, and weighs 35 pounds. This outfit has been in operation now for the past three months, working steadily, practically every day, with the exception of Sundays and holidays, and has given entire satisfaction in the points desired. It has proved well adapted for such work as widening out streets, excavating trenches for water and sewer pipes, and trimming off curves. The drills are so easily handled that holes may be put in at any point

[1] Claremont, New Hampshire.



Sullivan portable gasoline driven air compressor.

or at any angle desired. When boulders project into the street, it is a simple matter to drill a hole and blow off the projection with a little powder.

In the intervals of street work, the outfit is frequently hauled to the city trap rock quarry, where it is used for excavating stone for the crusher, to be used later on the roads.

In some parts of the town, where trenches have been excavated for water mains, disintegrated granite of a very springy nature was encountered, similar to loose shale. Progress in this rock was particularly unsatisfactory with the steam drills, and in fact, pick and shovel has ordinarily been the method of excavation. The hammer drills were found very well adapted for this work, and on one occasion, nine holes, five feet deep have been drilled and the rock blown out, in three hours' work. This task would have required at least two days, if done by hand. Much of this ground was wet and in some cases the water stood an inch or more in depth over the rock. The rock was so well broken up by blasting, as to pass, with the exception of only a few pieces, through a one-inch ring. It was easily removed by shovel, and made excellent macadam for the streets. In ordinary trench work, the rock is broken into pieces from two to three feet in diameter and removed by means of a light wooden tripod, mounted across the trench.

Still another class of work is found in extension of the streets in the suburbs. In the thinly settled parts of the city, the fields are covered with the glacial deposits of boulders. By using hose in 50-foot lengths on the drills, these boulders can be drilled for a distance of 100 feet at each shift of the compressor.

THE AIR COMPRESSOR

The air compressor is a standard Sullivan WG–3 single stage machine, with air cylinder 8 x 10 inches, compressing 96 cubic feet of free air per minute at 165 revolutions to 80 to 100 pounds pressure. This is sufficient to operate three hammer drills, although only two, one large and one small are now in operation. The illustration on page 405 shows the outfit in use, and the illustration on this page, shows the other side of the outfit. The compressor is geared to a 15 H. P. gasoline engine, and both are mounted on a substantial steel truck with heavy broad-tired wheels. The entire outfit weighs about 8,000 pounds. As will be noted from the illustration, it includes a gasoline tank, cooling tanks of a special design for the engine and compressor, and

an air receiver attached beneath the frame of the truck for the compressor. The outfit carries a day's supply of gasoline and it is only necessary to add one bucket of water every other day to the cooling supply.

At the rear end of the outfit is a hoisting attachment, driven by gearing from the engine, which has been found very convenient in removing boulders and rock fragments from the sewer trenches, and from the line of streets.

HAMMER DRILLS

The hammer drills are of standard pattern, using hollow steel with hexagonal shanks, fitting a hexagonal bushing at the nose of the drill cylinder. A double grip handle is furnished, and the operator uses this handle to rotate the steel. When the operator pushes the handle against the cylinder, the throttle opens, and the drill operates until pressure is released, when it automatically stops running. By a special arrangement of ports, it is possible to turn any desired proportion of the exhaust air into the hollow steel, thus keeping the hole free from dust or sludge, under all conditions, and securing greater capacity and speed than would otherwise be possible.

The valve and piston motion in these tools is so arranged as to provide a cushioning effect on the back stroke, which reduces the vibration of the tool to a very low point, and does away with much of the jar and fatigue usually experienced with hammer drills.

The DB–19 tool employs one-inch steel, the starters having a gauge of 1¾ inches, and the five-foot finishing steel a gauge of 1¼ inches. Seven-eighths-inch steel is used on the DB–15 drill, the starter being sharpened to 1⅜-inch gauge, and the last or three-foot bit being 1⅛-inch gauge.

RECORDS OF WORK

Records kept on the classes of work described above show that the hammer drills are doing about three times as much work as the tripod drills formerly accomplished. The cost of operation for the drills and compressor is about one-third less than that of the steam drills and boilers. Some of the performance records of the hammer drills are worthy of note. In sixteen hours' time, the DB–15 drill put in 47 feet in 25 holes, ranging from 19 to 36 inches deep, and the DB–19 drilled 19 feet or five holes running from 32 to 60 inches in depth. This includes loading, shooting, and all details, and further, the drills were not operated at the same time. Holes five feet deep have been drilled frequently in 30 minutes, and the best time noted for a hole of this depth is 20 minutes. This drilling was done in very hard dark green bastard granite.

Thanks are due Mr. George E. Merchant, street commissioner, and Mr. Nicholas F. Sleep, Superintendent of Streets, for information furnished the writer in preparing this article.

A hammer drill excavating a sewer trench.

Another instance of the convenience of these portable air compressors and drill outfits is furnished by the Keystone State Construction Company of Yonkers, New York, which is building a reservoir for the Board of Water Supply of New York City.

The ground is heavily covered with boulders, which it is necessary to remove from the basin, and the contractors are breaking these up as removed, for use in concrete. Until recently, this work was done by hand at a cost of $1.50 per man per day. As each man is able to drill about five feet of block hole per day, this shows a cost of 30 cents a foot for drilling.

The contractor has recently installed a Sullivan portable compressor outfit of the size and type described in the above article, together with three Sullivan DB-15 hammer drills. These tools are drilling an average of 50 feet each per day. The cost of operation is estimated as follows:

3 drill operators at $3.50 per day...	$10.50
Compressor attendant...........	3.50
Gasoline per day, 15 gallons at 20c.	3.00
Interest, renewals, wear and tear...	6.00
Total cost per day...........	$23.00

$23.00 divided by 150 gives a cost of 15½ cents per foot of hole, which means a saving of 14½ cents per foot over hand work, or $21.75 per day. The saving at this rate will rapidly pay for the equipment and of course secures greater speed.

There are hundreds of places throughout the country where an outfit of this kind might be used to advantage, on account of its compactness, portability, and economy of operation.

It deserves the special attention of mining companies on account of its economy of fuel and power. In this respect, and by reason of its portability, it should prove a valuable rig for light development work in mining country difficult of access, and where water is scarce.—(Editor.)

COAL PROSPECTING IN CENTRAL QUEENSLAND

Correspondence of "Mine and Quarry"

The accompanying photographs show some phases of diamond core drilling work in a virgin country. They were taken on the Dawson River, in Central Queensland, where the contractors, the Goldfields Diamond Drilling Co., Ltd., were engaged, in the fall of 1909, in testing a new coal field for the Queensland Government.

In this particular section the tangle of tropical forest prevented the government geologist from taking observations, while the formation, a huge saddle back, had few outcrops to guide him.

It was therefore necessary to prospect the area with a diamond drill, before the geologist could chart it. The drill had to be transported to many places hard to reach, and to test every corner of the field, in search for complete information.

The country is cut up and criss-crossed with gullies, creeks and rivers, and roads and bridges are few and far between.

The photographs show how the transportation problem was solved. The drill (a Sullivan Class "C," capacity 1,500 feet), its equipment, boiler, and camp outfit, were carried across these waterways on an improvised aerial wire rope tramway. Some of the creeks and rivers rose in a few hours from 30 to 50 feet above normal level. When the rains became general, the country was flooded for miles, and moving a drill at these times with horses or bullocks was impossible. By the "spider web road," however, moves were made without much difficulty. During flood times care had to be exercised to keep adequate supplies of food and fuel on hand, as the regular

The only dry road.

Sullivan drill engines crossing rough country.

paths were impassable for weeks, even for a horseman, and the nearest railway station or store was 40 miles away.

The results of the drilling work proved highly satisfactory in supplying the required information. The double tube core barrel proved of value by securing practically a complete core from the exceedingly brittle coal found in this part of Queensland.

An interesting detail of this drilling was the use of a special device for recording the direction and angle of dip of the strata. While the core would ordinarily show the angle of the dip, it fails to show direction, which was a matter of great importance in the anticlines of these coal measures.

This device places a due north mark on a piece of core, before it is broken from the bottom of the bore hole, and by an ingenious system of checks lands it on the surface without turning it from the position occupied in the formation, thus giving valuable aid to the geologist and mining engineer.

Sullivan Diamond Drills are used almost exclusively in all the Australian states. Twenty-five are owned and operated by the Goldfields Diamond Drilling Co. in its contract work.

A drill crew going to work.

One of the great stone plants

INDIANA OÖLITIC LIMESTONE

GEOLOGY, QUARRIES, METHODS

By George D. Hunter [1]

The Indiana oölitic limestone district extends from a point near Greencastle on the north, to the Ohio River, and ranges from two to 14 miles in width. The deposits are from 25 to 100 feet thick. The active quarries are confined to a comparatively small area called the oölitic belt, embracing Romona, in Owen County, Stinesville, Ellettsville, Bloomington, Clear Creek and Sanders, in Monroe County; Oölitic, Dark Hollow and Bedford, in Lawrence County, Salem, Washington County, and Corydon, Harrison County.

TOPOGRAPHY

The White River and its branches, Salt Creek, and numerous smaller streams, have worn what would otherwise be a plateau into gullies, ravines, and valleys, with an occasional gloomy hollow. The area is well wooded, except where, here and there, a bluff of limestone crops boldly out, or a knob of the original plateau shows at the summit of a hill. The quarries are usually opened on the slope of a hill, where natural drainage will carry off water.

Bloomington, one of the two headquarters points for oölitic stone, is a city of about 11,000 inhabitants. Here is located the Indiana State University, comprising a number of fine oölitic stone buildings. The town has several beautiful churches, also built of oölitic stone, and has recently erected a handsome Court House from oölitic stone quarried in Monroe County.

Bedford, the other leading city of the district, has a population of one more, or one less, than Bloomington (the writer refuses to say whether this refers to thousands or hundreds). Like Bloomington, Bedford has employed oölitic stone for numerous distinctive public buildings. Bedford is progressive. It owns more automobiles than Bloomington and takes more pride in its fine oölitic stone sidewalks, than Bloomington does in her paved streets (to be).

"Indiana oölitic limestone is one of the six great geological horizons which in that state comprise the lower carboniferous strata or Mississippian Period."

"The dip of these rocks over the region is from 50 to 60 feet to the mile, in a general southerly direction, making a larger area of stone accessible than if the structural position were more highly inclined.

[1] Bloomington, Indiana.

the Indiana oölitic district.

"Oölitic limestone is the thinnest of the subcarboniferous formations. It usually appears as a narrow outcrop from 100 to 400 yards in width, forming the flanks of low hills. But where it forms the surface rock over any extent of territory, as sometimes when it caps a wide ridge, the topography is gently undulating.

"Overlying most of the oölitic ston in the quarry region is a series of impure limestone, calcareous shales, and fossiliferous limestone, known as Mitchell limestone, from the town of that name, in Lawrence County. Its lower layers, just above the real oölitic stone, constitute 'bastard limestone stripping.'

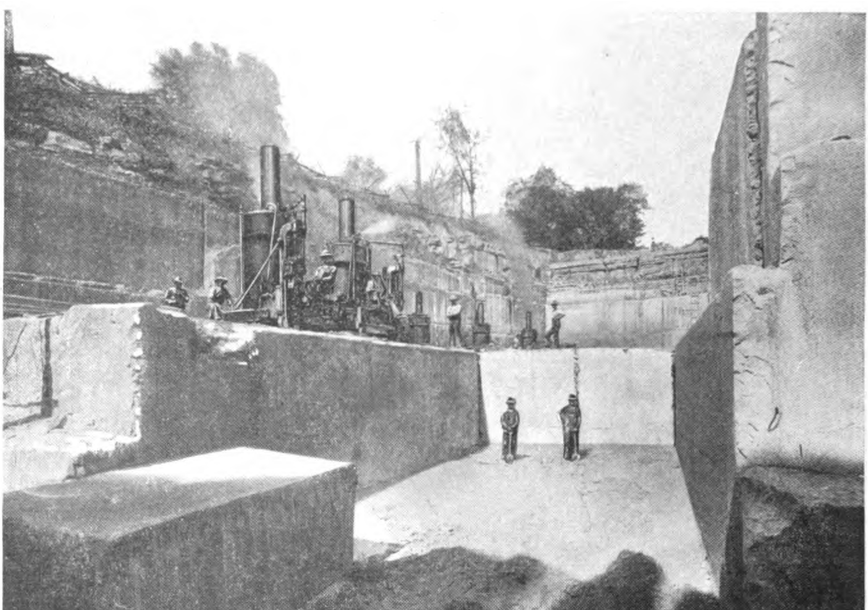
"In all outcrops and in many quarries there is at least one system of vertical joint seams and in most places two systems, one having a general east and west direction, the other north and south. Joint seams are rarely abundant, and in general range between 20 and 45 feet apart. Where solid rock covers the oölitic stone, the seams are seldom more than regular inconspicuous cracks in the rock mass and in nearly all places where the oölitic stone is not covered by solid rock, the weathering agencies have penetrated along the joint planes, forming irregular crevices generally two or three feet across. Most of these fissures are filled with clay and debris from the surface, and they are a great source of waste and annoyance to quarrymen, for the waste is not limited to the cavity. Irregular walls cause much waste in quarrying, and the closer together the cavities, the more waste, for it is seldom that irregular blocks can be broken to advantage. Where the quarry happens to be blue there is further waste, because along the joint planes the stone is oxidized irregularly, forming a strip of buff, varying in thickness on the two adjacent faces.

ANALYSIS AND CHARACTER

"An analysis of oölitic stone by average shows: Calcium carbonate, 97.62 per cent; magnesium carbonate, .61 per cent; iron oxide and alumina, .36 per cent; insoluble residue, .91 per cent. Approximately its specific gravity is 2.47, its crushing strength 7000 pounds per square inch, and its weight 152 pounds per cubic foot, though quarrymen, while calculating with reference to car capacities, give the stone a value between 170 and 180 pounds per cubic foot according as it is well seasoned or very 'green.'

"The physical tests show oölitic stone to be more porous than the average limestone, yet in crushing and transverse strength it is much above the average. Its flexibility permits it to withstand sudden changes in temperature of about 1,000 degrees without injury, a test which at first blush seems incredible.

Several "Y" channelers on one track—a characteristic practice in the district.



Five Sullivan channelers on the second lift.

"Like freestones, Indiana stone is softer and much more readily worked before than after it is seasoned, because it hardens with age. Yet it never becomes as hard or as difficult to cut as gritty siliceous rocks of equal strength, nor does it ever become as hard as marble. The lack of grit is a saving on tools and machinery. Besides, in the ease with which oölitic stone can be split diagonally and across the grain, it excels the average building stone. These properties make quarrying from a massive solid bed profitable, when harder stone or one more difficult to work would be an expense."

"How any stone of such softness when quarried, of such an even grain, so capable of being cut and carved almost with an ordinary jackknife, a stone which one commonly thinks of as being unusually easy to convert into lime and one which looks the part, could survive the severe fire tests put upon it, is a matter hard for the layman to understand. These qualities alone should commend oölitic stone to the architect no less forcefully than they surprise the layman."

SELECTION OF QUARRY LAND

The first step towards opening up an oölitic stone quarry, before making any great outlay of money, is to test the stone land with a core drill. Oölitic stone is so variable in formation, that several years' acquaintance are necessary to grade it properly. To the experienced eye, the core sample shows many characteristics, color, grain, and hardness, or defects of various kinds. Cores are taken out at divers places and as deep as the stone continues to be of good quality. The showing from the cores generally determines the location of a new quarry opening.

OPENING UP

When a new opening is decided on, a small space is stripped and one or two channelers put to work, cutting channels to a depth of four, six, or eight feet, as indicated by the core to be good stone. A derrick is raised to lift out the blocks.

Conditions in opening a quarry are so variable that it will be best to assume a floor already established by nature. The first channel may be termed a wall cut. Then another channel parallel with the first is made, say six feet away.

Cross cuts are next channeled, perhaps 18 inches apart, usually for a distance equal to the width between the two first channels. Large steel "bull" wedges with flat feathers, are driven in the first cross channel, and the block of stone broken off at the bottom. Steel derrick dogs are then made fast to the broken block in "dog-holes" cut at the opposite ends of the block with a hand pick, and the block is lifted out. This block is called a "key-block" and is carefully examined for imperfections. Spalls are broken from the edges of the block with a spalling hammer, for further examination. If the result is favorable, the next block is removed in the same manner, and when enough of these smaller blocks are removed to give working room for a small steam drill, the distance between cross channels is increased, and horizontal holes ⅞ inches in diameter are drilled seven inches deep and six inches apart at the foot of the block. The block is then split off by plug and feather wedges, and removed with the derrick. Key blocks channeled on four sides are difficult to lift, even after being freed on the bottom, on account of the fact that water and sludge in the cuts prevents air from getting beneath the stone, causing a vacuum. To prevent undue strain on the derrick, in such cases, a long pipe is attached to the steam or air hose and the sludge blown out from the cut, thus eliminating the suction or vacuum.

After the cross cuts have all been put down, long cuts are next channeled parallel to the first two cuts, and usually four feet two inches from the center of the first cut. This work continues until the whole floor is channeled.

A hydraulic stripper at work.

After the row of key blocks is removed cross channeling may be unnecessary. Oölitic stone as a rule has mud seams that run from east to west, and the long cuts should be at right angles to these mud seams, thus permitting the stone to separate at different lengths, 20, 30, 40 or more feet, which obviates cross cutting. These mud seams are generally from a few inches to several feet wide at the surface, but narrow as the stone is removed, until they become mere cracks in the stone.

FREEING THE BLOCKS

To remove the stone after it has been channeled into strips, it is first drilled by baby steam drills ("UA" Sullivan) along the bottom line of the channel, and plugs and feathers are used to break the stone. The stone is now turned over, to be broken up to the desired sizes (see page 418). Derrick "dog-holes" for hitches are made along the top of the channeled stone with hand picks. The hook ends of the dogs are placed carefully in the notches or holes, and one or more dogs are connected to a cable by loose sheaves with a clevis and pin to equalize the strain on all the fastenings. Power is then applied through the main fall cable, and with the assistance of bull-wedges, the large block of stone is freed and easily turned over. The floor on which it falls is bedded with small stones, which keep the block from breaking.

After the stone has been turned over it should be inspected by the quarry foreman, before any attempt is made to drill and break it to standard dimensions. When the stone is found free from defects, it is usually broken into large blocks, to be stacked; but for hurry orders, it will be broken to sizes to meet the order, lifted out of the quarry and at once loaded on a car for shipment.

ENLARGING THE QUARRY

This operation is repeated until the limit in depth of salable stone is reached,

over the area stripped. In enlarging the quarry area, the walls are examined closely for defects or changes in the stone. The location of these governs the depth of the channeling.

This may call for channels anywhere from 7 to 15 or even 20 feet deep. If the stone is uniform for 20 feet in depth, there will be a loss of one foot of stone for the entire length and width of the quarry, if removed by two 10-foot cuts, whereas if channeled at one cut, much valuable stone is saved, for the blocks may be broken into three widths if desired, and there is a further saving in setting channeler track, and in the additional labor of cleaning up an extra floor. The thickness of stone of a given grade is exceedingly variable, and to avoid waste, it is most important to establish a depth of channeling suitable to the quarry. For this reason a channeler such as the Sullivan "Y-8" is desirable. which can cut to any desired depth with speed and economy.

HYDRAULIC STRIPPING

The economical management of oölitic stone quarries demands constant planning and study, to meet changing conditions, as the quarries are enlarged. Stripping becomes an important factor, and should be kept ahead of actual requirements.

The soil in the Bloomington-Bedford district usually consists of hard red clay, frequently interlaced with roots and spalls. Stripping has until recently been performed with horse scrapers, but in the last year or two a large amount of this work has been done hydraulically, with water pumped to the location under pressure and played on the soil through special nozzles. A nozzle in general use fits a four-inch pipe and has a 1½-inch discharge tip. With it, the stream may be pointed in any direction, and a special form of play pipe enables it to be handled readily by one man, and to remain fixed without the use of anchors or fastenings.

The photograph on page 414 shows one of these nozzles at work. The hydraulic process has done much to reduce the cost of quarrying, and is bringing into operation valuable areas of stone hitherto neglected owing to the expense of stripping.

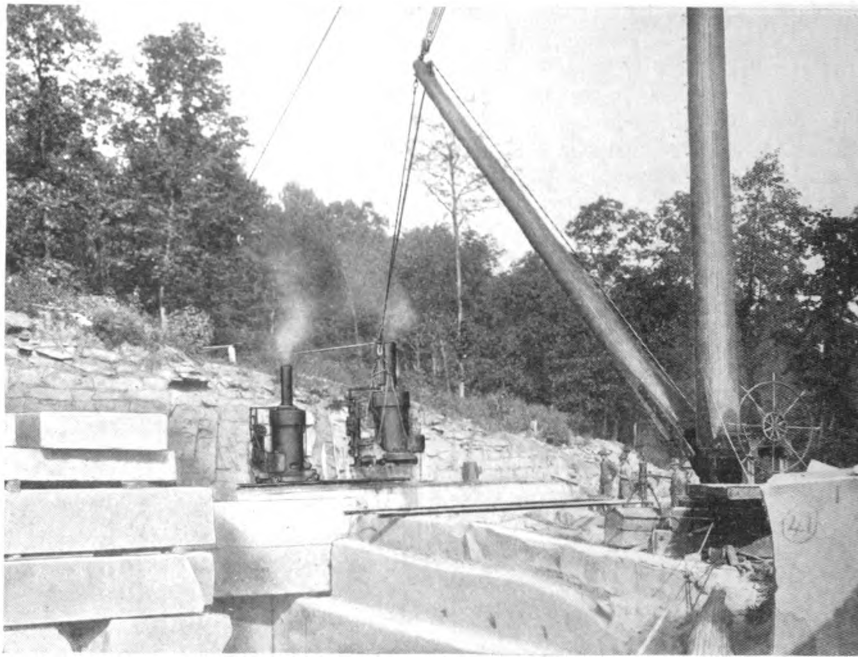
HANDLING APPARATUS

Another important factor is that of the addition of derricks and derrick power. The most economical power for this purpose is electricity, with a separate motor at each derrick. This secures a large saving in wire rope, and dispenses with many signal boys, as the power attendant can see at all times the work being done by the derrick crew. With the modern power rig is combined a power derrick turner. This enables the power man to operate the derrick, both for lifting and for turning, taking his signals direct from the head derrick man.

An interesting device is employed to handle the channelers, when out of reach of a derrick. This consists of a wire cable, made fast to a tree or stump, or any solid footing beyond the channelers, with the other end connected to the derrick boom. On this cable is a carriage, running on two pulley wheels, and having a swivel hook on which the channeler chains or slings are hung. When the channeler is to be handled, the boom is lowered until the sling can be connected to the swivel hook. The boom is then raised, bringing the cable taut, thus lifting the channeler, to permit turning it around, or removing it to another track set ready to receive it. A wire rope is fastened at one end to the carriage, and the other end is attached to the main derrick fall, with which the carriage is moved along the suspended cable. This aerial tramway is also used at times for carrying blocks of stone to a suitable dumping ground, or for other like purposes, out of reach of the derrick. (See photograph on page 416.)

CHANNELING

The channeler question is also a most important factor. Practice in oölitic stone



Handling channelers outside derrick radius.

quarries differs in this regard from that in other building stone quarries. Overlying rock must be channeled, as blasting of this cap rock is seldom permissible. If there is to be any shooting or blasting for stripping purposes, only black powder should be used, and with great care, to avoid injury to the underlying oölitic stone.

POWERFUL MACHINES ESSENTIAL

Aside from the varying hardness of the overlying stone, the depth to be channeled also varies. If it were always possible to have a free or open end cut for the slush to run out of, the depth cut by the channeler would hardly require mention. But at times, particularly when starting a new quarry, the cut is closed, or has a blind end, affording no outlet for the slush. Channeling from 8 to 15 feet deep in blind cuts requires power to lift the long steels sufficiently to give blows of proper force. It is not the weight of the long steels alone that requires power, but in lifting the steels through the stiff slush, a vacuum or suction pulls against the engine, retarding the blow.

The power must be ample to lift the drills quickly and drive them through the slush onto the solid rock, with sufficient force to cut the rock economically.

The illustrations on page 412, and 418, show a feature, which, while perhaps not now peculiar to this district, at least had its origin here, viz., the operation of two or more channelers in gangs or batteries, on one long track. This practice secures a rate of cutting considerably higher than can be attained ordinarily by a single machine, since the action of the cutting bits of the battery tends to keep the slush at the bottom of the cut churned up, and prevents it from forming a cushion on top of the uncut stone.

CHANNELERS IN USE

Two general types of channeler are used in this field, the old-fashioned double gang pattern, with locomotive boiler and cam drive, and the direct acting, single gang machine, with vertical boiler.

In oölitic stone, for the reasons stated above, the best channeler is the one that can strike the hardest and fastest blow, and put in the deepest cuts without loss of efficiency. In the past few years the machines employed have been replaced by heavier and more powerful types, to meet increasing demands for speed in production.

The most modern channeler in the field, based on and designed particularly for these conditions, is the Sullivan "Y–8." This machine has an eight-inch cylinder on its main or chopping engine, as compared with the seven-inch cylinder of the Sullivan "Y," the most powerful machine previously employed.

The chopping engine on these channelers is of the straight line or direct acting type, thus eliminating all cross strains at the instant of delivering the blow or lift. It has a 24-inch run or feed on the standard, against 18-inch in other makes. This is an important factor in economy of time and labor in changing the drill steels, as well as saving two sets of gang steels, in cutting to a depth of only 12 feet. The engine has an exceptionally large and heavy cross head, running at all times "within the guides" (a feature not offered in any other channeler). These guides are of the best bronze, having the greatest amount of bearing surface possible. The chopper engine is thus able to withstand heavy service without trouble, and the momentum given to the blows by the weight of the cross head adds power to make the steels cut the stone under the most severe conditions.

For running over mud seams or broken stone, the machine runner cushions the blow by a single movement of a cushion valve within easy reach.

CUTTING SPEED

The cutting efficiency of all channelers in oölitic stone is remarkably variable. The medium hard oölitic stone chips nicely when the steel strikes the rock, and with open-end cuts these particles are carried away by the water, and the cutting speed is good. Some of the softer stone may rightly be termed "tough." Sink the steels deep into this stone, and it has a tendency not to chip or break away but to "rag" away. The fine particles (practically dust) settle at once in the open space made by the gang steel points in the soft rock, and do not wash out of the channel readily, even when the cut has a free end, thus retarding the cutting efficiency.

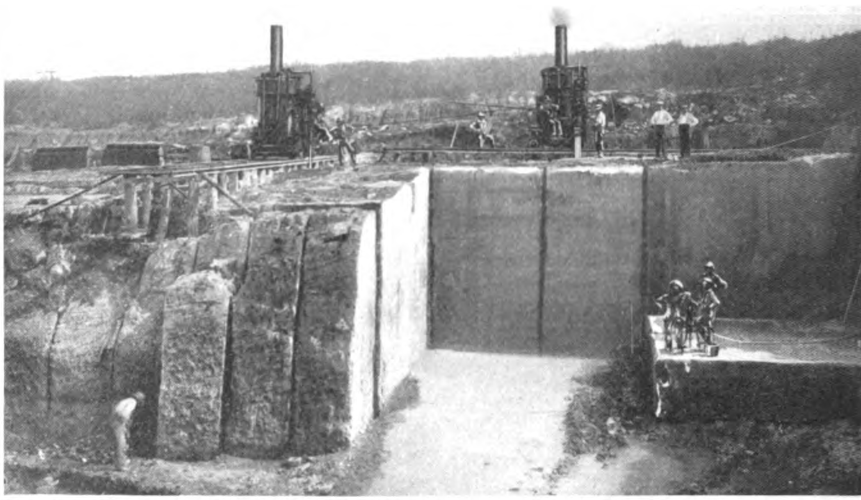
There are other soft oölitic stones that break away as nicely as the medium hard, and here the cutting efficiency is equal to or better than that in the medium hard.

An average day's cutting (10 hours) for a Sullivan "Y-8" machine will range from 300 to 600 square feet, month in and month out, depending upon the local quarry conditions mentioned. There are of course, higher records for individual machines and shorter periods.

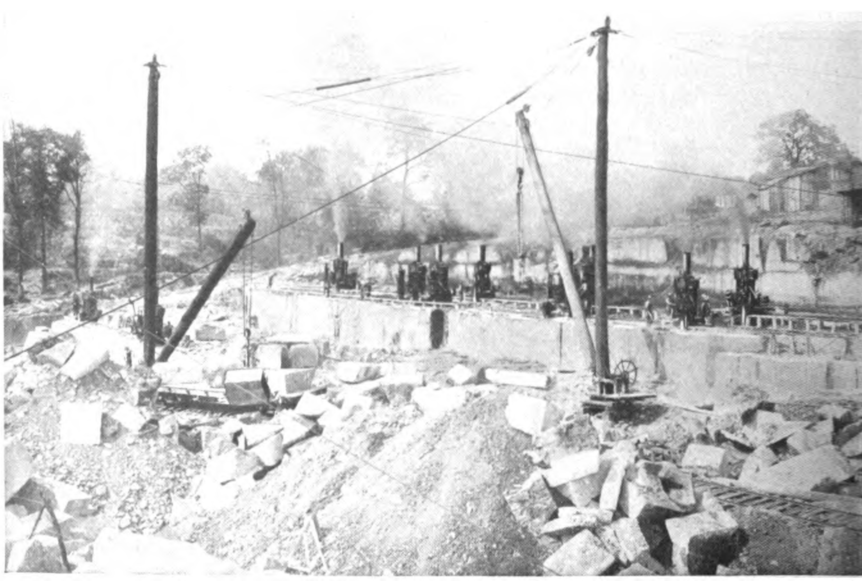
CHANNELER BITS

The manner of forming the steel points, or teeth, is of interest here, as it differs from the arrangement used in hard stones, such as marble. For the oölitic field the accepted standard is to sharpen the diagonals right and left thus, |/|\|; for marble the diagonals are the same, thus, |/|/|. (In marble, if the diagonals were made right and left, there would be too much tendency to twist, their cutting edges not remaining at the same angle.) The right and left diagonals cause the oölitic stone to break away more readily, rather than "rag" away from the blows.

The quarrying of oölitic stone demands constant watching of every channeled block; when the stone is "turned over," to be broken in dimension sizes, the foreman of the quarry must exercise great



Sullivan Y-8 channelers cutting 20 feet deep: this view shows a quarry block turned over and being split with drill and wedges.



Ten Sullivan channelers in a well developed quarry.

care; must learn the location of every defect, and be governed by it, otherwise great loss of good stone will be the result. When the quarry runs free from defects, such as "glass seams," invisible "drys," irregular sizes of grain, or unnatural spots or marks (such conditions *do* exist), it may rightly be called a "gold mine." It takes such finds to overbalance the amount of stone sent to the grout pile, and other losses, to make a showing at the end of the year on the right side of the ledger.

QUARRYING SEASON

Oölitic stone for building purposes is quarried from March to November first (eight months of the year). Earlier or later quarrying involves great risk against loss of stone from freezing, as the stone is full of sap or water.

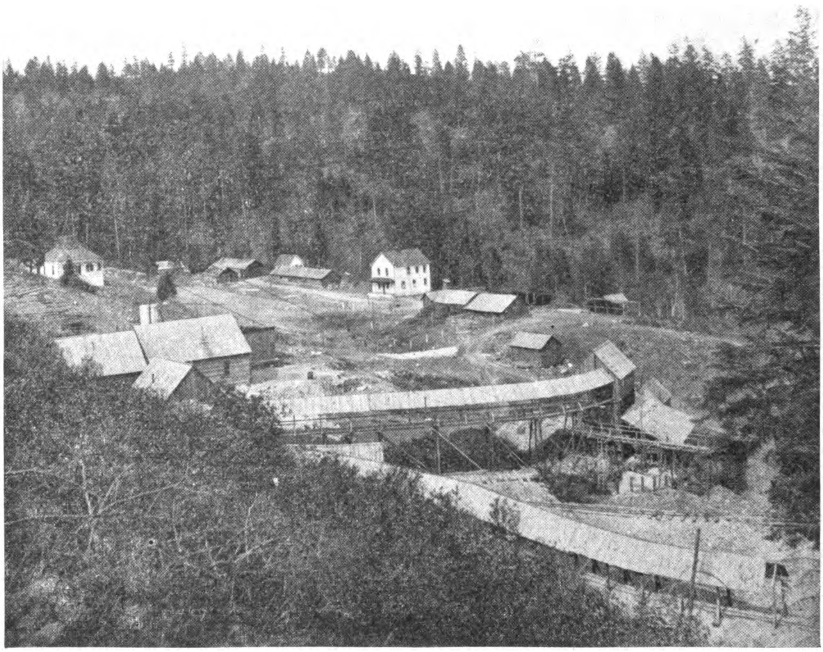
Again, there are some quarries in the oölitic stone territory that permit channeling in freezing weather, since for some known or unknown cause the stone is practically seasoned before being quarried. It only takes a day or two, in mild weather, for oölitic stone to season sufficiently to avoid danger from freezing When oölitic stone freezes, no parts of the stone are left solid. It just crumbles up. If seasoned, the openings that held the sap or water close and seal up as the water evaporates, and the weather has no disturbing effect if the atmosphere is free from sulphur gases.

No attempt will be made here to describe the cut stone industry, and the methods employed at the mills. In this department the practice is as fully abreast of the times as in the quarries themselves, and a visit to the great cutting plants fills an outsider with wonder at the variety of the things done to the stone, and the facility and speed with which work is accomplished.

The photograph on this page shows a train of six cars, each containing a single block of oölitic stone weighing 70,000 pounds. These were recently sent to a Paris sculptor, to be carved into six groups and returned to this country to adorn the new residence of one of America's wealthiest men. A list of important and beautiful structures in which this wonderfully durable, but wonderfully compliant stone has been used, would fill several issues of this magazine.

The writer is indebted to many friends in the Bloomington-Bedford district for numerous courtesies rendered in connection with the preparation of this article. Space has forbidden the use of many interesting illustrations, and the mention of individual quarries and companies. Much friendly rivalry exists between sections of the district, but when it is "oölitic against the field" all pull together.

The writer acknowledges indebtedness for portions of the geological description to the very complete reports of the state geologist, Mr. W. S. Blatchley, and his assistants, R. S. Blatchley, C. E. Siebenthal, and T. C. Hopkins.



First Thought Camp, Orient, Washington.

THE FIRST THOUGHT MINE

By C. W. Bucklew[1]

The First Thought Mine is located about three miles from the town of Orient, Washington, and is owned principally by Canadian capitalists. The First Thought Gold Mines, Ltd., operates the mine. The amount of dividends has not been made public, as it is a close corporation, but the owners are satisfied with the mine's steady productiveness.

The ore bodies occur in an andesite formation. The dyke varies in width from five to 50 feet. A general view of this dyke is shown on page 421. The following is the present analysis of the ore: Gold, 1 oz.; seline, 1 oz.; silica, 60 per cent; sulphur, 3 per cent; iron, 8 per cent; lime, 10 per cent; alumina, 14 per cent; moisture, 3 per cent. The average gross value of the ore is $20 per ton. Treatment charges, including freight, average $6.00 per ton. It is impossible to distinguish ore of value from worthless rock without assaying.

Owing to the refractory nature of the ore, the smelters are able to handle only a limited quantity, which is used principally for converter linings. However, the mine has shipped at the rate of about 15,000 tons per year for the past five years. The lack of timber in sufficient quantity has led to the use of gasoline engines as prime movers at this plant. A 60-H. P. gasoline engine is used to drive by belt a 14 x 9 x 10-inch Sullivan two-stage class "W J" air compressor having a piston displacement of 338 cubic feet per minute against a pressure of from 80

[1] Spokane, Washington.

to 100 pounds. This compressor furnishes air for five air hammer drills, a Sullivan Diamond drill of the "Badger" type, and a mine pump. These hammer drills are used for stoping and crosscutting, as well as sinking. The present workings are about 500 feet deep. Above the 200-foot level the mine is worked through a crosscut tunnel. More than 6000 feet of development work have been done. Data are not available at this time as to the average drilling done per shift, nor the costs per foot. The diamond drill has performed about a thousand feet of work, taking out a 15-16 inch core. The gasoline engine requires about 8 gallons of distillate per hour.

A 15 H. P. gasoline engine is used for hoisting purposes, from a winze 150 feet deep, sunk from the 200-foot level, and the ore is delivered to the tram loading station with the usual complement of ore cars.

The aerial tramway was furnished for a capacity of 50 tons per day. It is about three miles in length, and requires a man at each end to load and unload the buckets, which are fastened securely to the single rope. A 15 H. P. gasoline engine operates this tram. The ore is loaded into standard railroad cars at the terminal bins and shipped to the British Columbia and Tacoma smelters.

Andesite dyke, containing ore bodies, 5 to 50 feet wide.

Under the capable management of Mr. Alexander Sharp this property will no doubt develop into a great mine. Experiments have been going on intermittently for some time past to determine an efficient process for the treatment of the ore on the ground. As soon as the proper system is determined, the property can be worked on a much larger scale.

OUTLINE OF THE MIIKE HARBOR AND DOCK WORKS

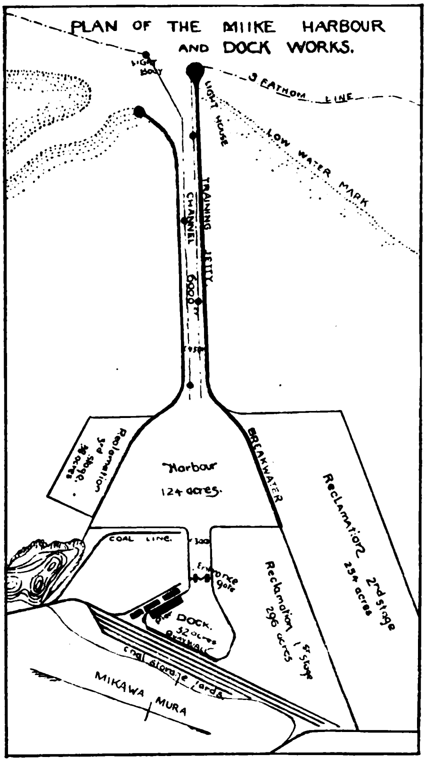
NOTE.—The Mitsui Mining Company is a branch of Mitsui & Company, one of the largest and most influential of the great Japanese commercial and industrial firms. In order to provide a better and larger equipment for shipping coal from certain of its numerous mines, the harbor and docks described below have been constructed. The article was written by one of the company's engineers in 1908, since which time, much of the work contemplated has been executed.—*Ed.*

OBJECT

The Miike harbor works are a private undertaking of the Mitsui Mining Company, designed principally to facilitate the export of coal from the Miike Colliery, one of the company's properties.

SITE

The site is in Mikawa village, "Miike" district, in the south of Chikiigo province, bordering on the Shimabara Gulf on the one hand, and Higo province on the other, latitude, 33° 00′ 45″ N., longitude, 130° 24′ 50″ E., and is only 38 nautical miles distant from Kuchinatsu, the present port of shipment of "Miike" coals. The new harbor has every promise of becoming in the near future, a flourishing center for the distribution of goods. The design of the harbor is shown in the sketch on page 422.



Plan of the Miike harbor works.

RECLAMATION OF THE SEA FRONT

The reclamation of the sea front is to be carried out in three stages, for the purpose of obtaining space for the storage yards, for railway sidings, for building a new town, and for various purposes connected with the development of shipping business. The area to be reclaimed is as follows: in the first period, about 296 acres, in the second period, 254 acres, in the third period 38 acres.

THE WET DOCK

The wet dock is to be used principally for coal loading, and has a surface area of 32 acres at high water level. The depth within the dock is constantly kept not lower than 28 feet, by means of dock gates. Moreover, the front of the quay wall has a normal depth of 30 feet, which increases to 38 feet at high water line. It will be capable of accommodating eight or nine big vessels at the same time.

QUAY WALL

The quay wall is 1,380 feet in length, 41 feet, 6 inches in height, having a batter of one to 20 on the front side, and is constructed at the eastern extremity of the dock, for the simultaneous accommodation of three big vessels.

On the quay wall are to be installed several sets of "Miike quick loading machinery," to provide a loading capacity of upwards of 10,000 tons of coal per day, about double the present output of the Miike coal mines.

THE DOCK GATES

The dock gates which control the water level in the dock, form the most important part of the works. The width of the passage is 66 feet, and at normal level, it has a depth of 28 feet on the sill in which the gates work. The gates, which have a weight of 90 tons each, are worked by means of hydraulic machinery.

IRON PIER

An iron pier, 300 feet long and 75 feet wide, is constructed along the southern side of the dock for the accommodation of vessels, which may bring general cargoes, such as raw cotton, foreign rice, bean cake, etc., on their inward trips.

INNER HARBOR

The inner harbor is that portion of the sea, bounded by breakwaters and sea walls as planned for the first stage of reclamation, and its total area covers about 124 acres. At the present time, a channel across the central part of the harbor and some anchorage space have been dredged out, but the deepening of the remaining section is to be undertaken in due course.

When the entire dredging is completed, the portion to the north of the channel will be set aside exclusively for public use.

CHANNEL

The channel, extending from the inner harbor to the sea, is 6,000 feet long, having a depth of 18 feet at lowest tide. It is protected from the waves and intrusion of silt by means of two parallel jetties. The structure of these jetties is similar to that of the breakwater, having a height of one foot above high water level and a breadth of 12 feet. The distance between the two jetties, measuring from center to center is 450 feet.

A water course, 150 feet wide at the bottom, and 18 feet deep at low water, is already dredged out, and to cope with increased shipping traffic in future, it is to be widened to above 250 feet, so as to enable vessels to pass each other.

LIGHTHOUSE AND LIGHTBUOYS

For the convenience of shipping at night, the entrance to the inner harbor is distinctly marked by a lighthouse, standing at the end of the northern channel wall. The focus of the light is 45 feet above the high water line and the character of the light is occulting (flash) which renders it easily distinguishable from other lights. A number of lightbuoys are also moored on either side of the channel to secure further safety of vessels.

COAL STORAGE YARDS

The coal storage yards adjoin the quay wall. The one at the back of the wall has a special equipment. It consists of five rows of trestles built upon brick arches, underneath each of which is provided an electric railway track for its loading of coal from the storage pit above, by opening doors on either shoulder of each brick tunnel.

The coal gravitates into cars placed on the track. A train consisting of five or six cars is drawn by an electric locomotive, and the contents are transferred to the coal loading machine. The empty cars are devised to run down to the lower level sidings and are thence returned to the tunnels to receive a fresh supply.

These especially equipped piers have an aggregate storage capacity of about 50,000 tons and are to be chiefly used for lump coals. For storage of the bulk of the slack coal, ordinary trestles are to be provided.

LOADING MACHINERY

For the shipment of coal, two or three sets of patent "Miike quick loading machinery," made to move laterally along the wall, are to be installed. Each unit is capable of loading coal at the rate of 6,000 tons per 24 hours. Two of them are to be installed at first, to provide a shipping capacity of upwards of 10,000 tons of coal.

These plants can handle coal, either from cars coming directly from the mines or from the storage piles, and the capacity per lift is eight tons.

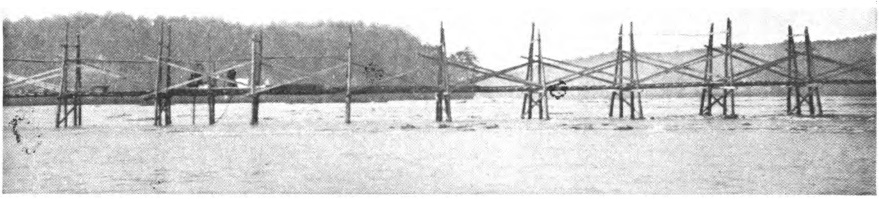
RAILWAY ACCOMMODATION

A railway line covering a distance of two miles, 40 chains, is to connect the dock with the Manda mine, which already has a railway communication with the rest of the Miike mines, and a railway connection will also be made with the main Kinshu railway line in the near future, depending on the increase in traffic.

BREAKWATER

The breakwaters bounding the inner harbor, about 3,000 feet long each, are of the rubble mound type; the top of the wall is eight feet above high water line, and the width 15 feet.

Along the dock wall, Miike Harbor.



Drilling trestle across the Chattahoochee.

SELECTING A DAM SITE WITH DIAMOND DRILLS

By H. L. Avery[1]

The Columbus Power Company is engaged in the construction of a dam across the Chattahoochee River, at a point about 15 miles north of Columbus, Georgia, just north of the Harris County line. This structure, which will be known as the Goat Rock Dam, will cost, together with the power house, $1,500,000, and will develop about 24,000 horse-power. This power will be used for mills and factories in Columbus and adjacent points. The dam will be 1,375 feet long, 75 feet high, and will contain 120,000 cubic yards of concrete. The power house will be situated at Goat Rock on the Alabama side of the stream, and is to be about 150 by 170 feet in area. The power generated by the water in its fall of 80 feet will be converted into electricity by hydraulic turbo-generators.

The Stone & Webster Engineering Corporation of Boston, the engineers of the undertaking, decided to ascertain the exact nature of the river bed and the formations below it, and for this purpose, engaged the services of the Sullivan Machinery Company of Chicago, to secure a set of diamond drill cores. The previous experience of the engineers with diamond drilling at the Hauser Lake and Wolf Creek dams, on the Missouri River, near Helena, Montana, had demonstrated the reliability of this method of testing.

[1] Resident Engineer, Stone & Webster Engineering Corporation, Columbus, Georgia.

The contractors began work in March, 1910. Their outfit consisted of two drills, a "Badger" and a "Beauty," removing a core seven-eighths of an inch in diameter, and two steam boilers on wheels, one for each drill.

At Goat Rock the Chattahoochee is broken by a sharp flight of rapids, and the water, while only four to nine feet deep, flows with great swiftness.

It was impossible, owing to the current, and to the likelihood of sudden changes in the water level, to support the drill and boiler on a scow, as was done in the Missouri River work.[2] After some study, a trestle was built out from the Georgia bank 1,100 feet to the Alabama shore. Poles of suitable size were cut in the woods along the shore, and set and braced in the manner shown on this page. Boulders were wheeled out on the structure as it advanced and dumped around the feet of the poles to give them stability.

Nine holes were bored from this trestle, to an average depth of 16 feet, in very hard, solid rock, chiefly hornblende. Eight other holes, making 17 in all, were bored from temporary stagings or landings, as shown on the next page. These were made just large enough to hold the drill, pump, and crew. Steam was run to the platform from the boiler

[2] See "Mine and Quarry" for September, 1909 —Ed.

"Badger" drill on staging.

on the shore through piping supported on crossed planks.

Some excellent cores were obtained, one of which was four feet long. The drill, under the able superintendence of the foreman, Mr. E. H. Gribble, gave results which were satisfactory, and the construction of the dam will be started at once. The estimated time of completion is three years.

Power, for the construction of the dam, will be furnished by induction motors, operating air compressors, which in turn will operate compressed air engines. The electricity will be generated in Columbus, at 11,000 volts pressure, three-phase alternating; transmitted to the dam, and stepped down to 2,300, alternating, for use in the motors. The job will be electric lighted. Mr. Wm. V. Polleys is engineer in charge of all of Stone & Webster's construction work in and around Columbus, and the writer is resident engineer on the dam.

Readers who have copies of the March, 1909, Mine and Quarry which they no longer need, will confer a favor by mailing them to the editor.

Mine and Quarry is pleased to accord a leading place in this issue to the Indiana Oölitic Stone industry. The author has complained that the space allotted him is ridiculously small, and that he cannot do his subject justice in less than a double special number; and, indeed an industry boasting nearly fifty quarries, as many mills, nearly four thousand operatives, and an annual production of over twelve million yards of stone, valued at four millions or more of dollars, deserves more attention than is possible in one meager article. It is, therefore, with an apology for its inadequacy that this sketch of the oölitic quarry district and its methods is presented. In later issues it may be possible to discuss some of these many interesting details at greater length.

If Mine and Quarry is your idea of nothing to read, to quote a contemporary, please tell us, and we will stop your paper. If it contains matter that helps or interests you, we shall be glad to hear from you, too.

Mine and Quarry is now at home to its friends in new quarters on the fourth floor of the People's Gas Light and Coke Company's twenty-two story building, 150 Michigan Avenue, Chicago.

MINE AND QVARRY

VOL. V. No. 2 OCTOBER, 1910

A WATER POWER SITE ON THE CLACKAMAS RIVER, OREGON

PVBLISHED BY THE SVLLIVAN MACHINERY CO. 150 MICHIGAN AVE., CHICAGO.

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MINE AND QUARRY

Vol. V, No. 2 OCTOBER, 1910

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

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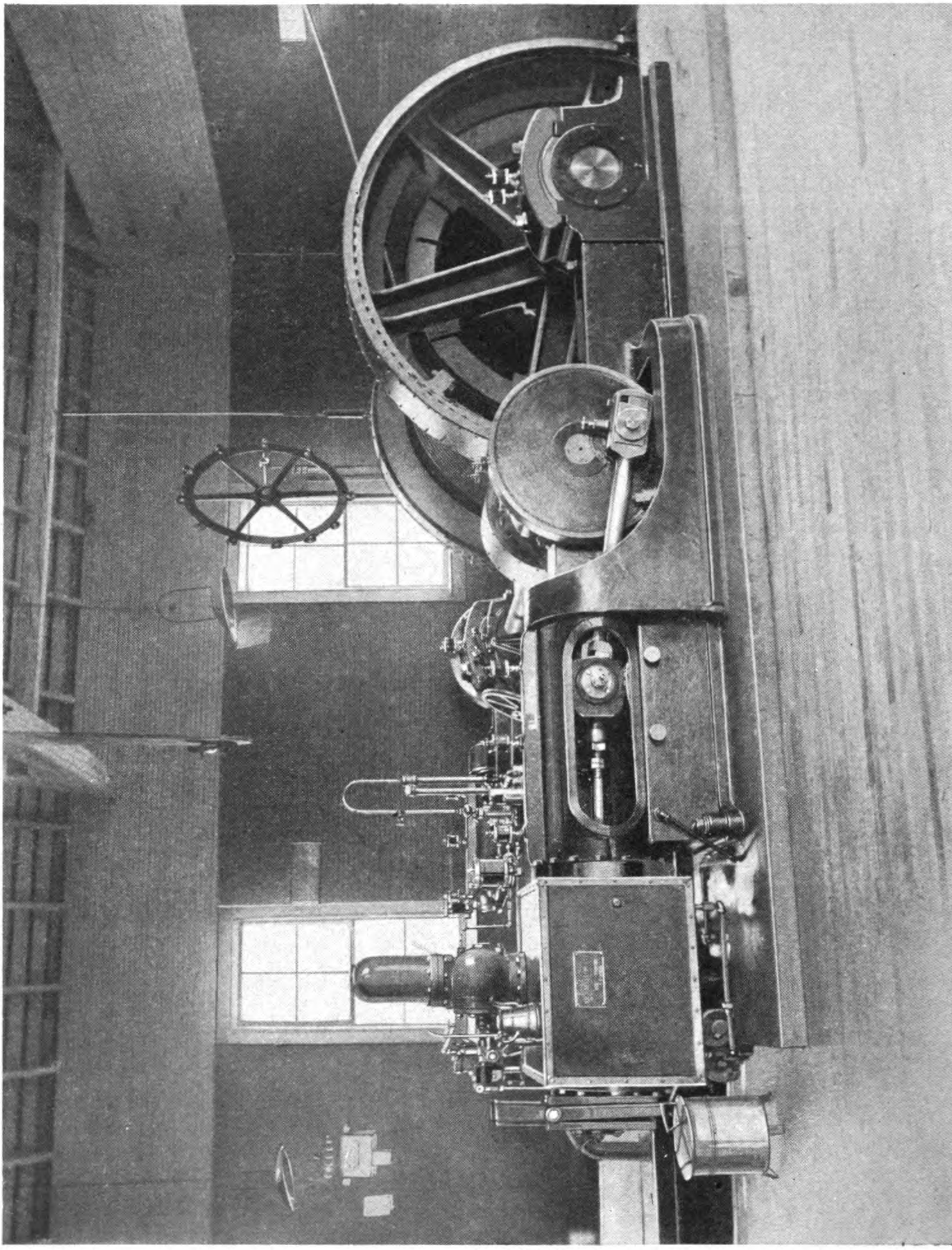
Readers are requested to notify MINE AND QUARRY of any correction or change in address.

MINE AND QUARRY'S list of readers continues to grow at a healthy rate. If you are one of those who find no interest in its pages, or if its visits are a cause of annoyance, please write "discontinue" and your name and address on the card, and mail it; the trouble will cease at once. On the other hand, the return of the card as an acknowledgment of the paper, will insure its regular arrival and will prevent the cancellation of your name in revising address lists. Your suggestions and criticisms are always welcome.

The advantages and benefits of undercutting coal by machine and the dangers and losses of "shooting off the solid" are convincingly stated in the article by Mr. Edward W. Parker, statistician of the United States Geological Survey, a portion of which is reprinted elsewhere in this issue. Coal operators who still employ the old-fashioned method, should not pass this paper by unread. For them it contains much food for careful thought. The percentage of coal mined by machines in this country has increased from 28.80 in 1904 to 37.52 in 1908. In Illinois, a state in which low wage differentials have made solid shooting a favorite method, machines cut 19.5 per cent of the total product in 1904 and 34.2 per cent in 1909.

The Buckeye Mine of the Commonwealth Iron Company at Commonwealth, Wisconsin, is a good example of modern Lake Superior practice in its working methods and equipment. Although this is still a young mine, the surface plant is calculated to give as high a degree of operating economy as would be thought necessary at a full developed property. The owners know that a penny saved in running expenses is truly a penny earned. This plant and the methods employed are described on another page.

The localities and industries in which fuel oil may be used to advantage and at a saving over present methods, are too numerous to mention in these notes. While a considerable advance has been made in the study of oil burner systems, the evidence thus far collected shows that no hard and fast set of rules can be formulated which will give efficient and economical service under all conditions. Each installation is to a certain extent, special, and must be studied and worked out to conform to local conditions. Many plants have condemned the oil burner system for their own work simply because the matter has not been properly investigated or the advice of competent engineers has not been available. Every phase of each situation should be carefully considered before reaching a decision. If experiments with low pressure do not give proper results, higher pressure should be tried. If one type of burner seems to produce poor results, try others. In numerous cases careful experiments have resulted in handsome economies in fuel and increased efficiency. Some notes on this topic will be found on another page.



Sullivan hoisting engine at the Buckeye Mine.

Head frame and mine buildings of the Buckeye Mine.

THE BUCKEYE MINE

MODERN METHODS ON THE MENOMINEE RANGE

By L. J. O'Grady[1]

The development of the iron ore deposits on the Menominee Range in Upper Michigan is going forward rapidly. The older mines, many of which have been producing for a quarter of a century, give promise of continued production for years to come, while new explorations are taking their places at frequent intervals in the ranks of producing mines. On every hand the diamond drill is boring deep into the earth in search of more deposits. Thriving towns are springing up in the iron country. Many older towns that saw their rise and decay with the disappearance of the pine forests are beginning a new prosperity with recent discoveries of iron ore.

Part of the Menominee Range is in Wisconsin, due to the fact that the Menominee River, flowing through the range, forms the boundary line between the two states. The presence of iron in this section was determined in the early sixties, and mines have been shipping since 1877. In early times the Indians knew of these iron ore deposits, as Loon Lake was called by them Lake Komon, the Indian word meaning iron.

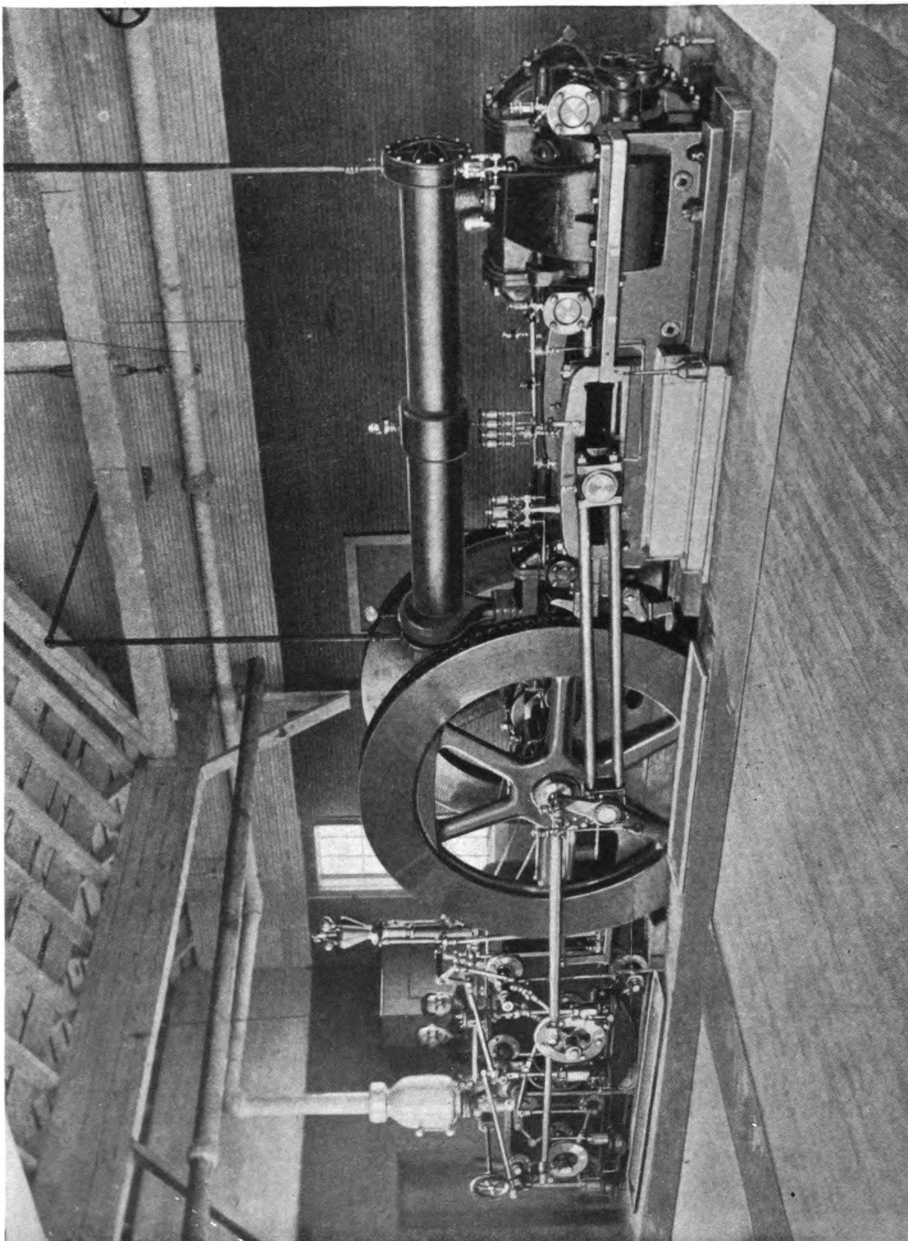
[1] Ishpeming, Michigan.

Systematic development work was begun by the Commonwealth Iron Company about 1877, and their mines, three or four in number, produced regularly until 1890. This early work consisted of test-pits, shaft sinking, and the old time hammer and drill mining. To-day the diamond drill, rock drill and modern power equipment enable this work to be done much more quickly and cheaply.

THE BUCKEYE MINE

After several years of drilling and exploratory work by the Commonwealth Iron Company, the Reserve Mining Company has recently developed its Buckeye mine, the output in 1909 being 50,000 tons. This year the output will be almost trebled and a large future production is assured.

The workings are about a mile and



Sullivan Corliss tandem two-stage air compressor at the Buckeye Mine.

Sullivan rock drill on tripod drifting in the Buckeye Mine.

one-half south of Commonwealth, Wisconsin, not far from some of the old workings of the pioneer company. The ore is a medium-hard red hematite, containing a good percentage of iron, and analysis shows it to be of an excellent grade for furnace work. It does not break too fine, being what is known as "lumpy," and therefore mixes well with the finer ores from the Mesaba Range. A single compartment shaft is down 300 feet, and ore is being mined on three levels. During the coming winter, sinking will be continued to the fourth and fifth levels. The mine is comparatively dry, and pumping is a small item.

WORKING METHODS

The ore is mined by back-stoping. From the main level drift, raises are driven to a height of 15 feet and timbered for use as chutes. One raise is driven from level to level for ventilation. The ore is broken into the chutes, and the pile carried up almost to the level above. In this way about two-thirds of the ore can be stocked in the mine during the winter months. When the stopes are finished, the ground left between the levels is shot down into the chutes. The man-ways are carried up in the rock, and small drifts opened into the stope as the pile grows. This differs from some western practice with which the writer is familiar, in which square-set timbered man-ways are carried up at either end of the stopes, sets being added as the pile grows higher.

For breaking the ore, Sullivan "UC" (2¾ inch) rock drills are used exclusively, and the raises are put up with hammer drills of the same make. These latter drills are also used to good advantage for

Sullivan stoping drill "block holing" a boulder in a chute.

breaking up boulders in the chutes. Instead of laying powder on the fragment to be broken, and thus risking damage to the chute, block holes are drilled as shown in the illustration. This also results in quite a saving of powder. When the shaft is continued from one level to another, a winze is sunk in the ore some distance from the shaft to the lower level. Then a drift is run to a point directly under the shaft, and it is then "raised" with hammer drills (as described in the April, 1910, Mine and Quarry). For sinking and heavy driving, Sullivan "UE 2" (3⅛-inch) drills are used.

SURFACE PLANT

The ore is brought to the surface by a Sullivan automatic cut-off slide-valve hoist. This machine has 14 x 18 inch engines, and a drum 6 x 6 feet. It will handle a five-ton skip to a depth of 800 feet. At present a two-ton skip of the DeBeers type is used. The hoist is one of the very latest type, of which several are already in use in this field. It was especially designed for small or growing mines, and by means of the patented automatic cut off arrangement, a fuel economy is secured equal to that of a Corliss hoisting engine. In the engine house, together with the hoist, is a Sullivan "WC" tandem compound Corliss two-stage air compressor, having a capacity of 1380 feet of free air per minute. Power is furnished by two 150 H. P. return tubular boilers.

The surface equipment comprises sev-

eral new and substantial buildings. A machine shop containing lathes, drill presses, planers, etc., takes care of a great deal of local work. There is also a new engine and boiler house, blacksmith shop, offices, and drying house. This building is well equipped with lockers and toilet facilities, and is a commodious and up-to-date change room. In this building is set aside a room containing tables, cots, and a supply of surgical supplies where first aid is given in case of accident. Needless to say, such conveniences and arrangements are greatly appreciated by the working force.

With the equipment and mining methods outlined above, the Buckeye Mine is an example of the latest mining practice. Moderate first cost has been retained, while the economy derived from reduced fuel consumption rivals that of some of the largest mines on the range.

The writer is indebted to Superintendent F. G. Smith, in charge of the property, for his courteous assistance in preparing these notes.

DIAMOND DRILL BORINGS ON THE CLACKAMAS RIVER (OREGON)

By V. J. Hampton[1]

The Portland Railway, Light & Power Company operates a large hydro-electric power plant at Oregon City, on the Willamette River, 14 miles above Portland, and a similar plant at Cazadero, on the Clackamas River, 35 miles above Portland. These plants supply power to operate the street railway system of Portland, and also supply electricity for lighting and commercial power purposes in Portland and the surrounding towns.

Last year the company decided on the immediate construction of two more power plants on the Clackamas River. For these two plants, four sites were available. It was necessary to consider the especial features and natural advantages favoring each particular site, before proper selections could be made. The location of the Cazadero plant, now in operation on the Clackamas River, also influenced the choice. Three of these available sites were about three and one-half miles below the Cazadero plant, at a point known as River Mills. These sites were designated as Site A, Site B, and Site C. There was also a site available above the present plant, known as Site D.

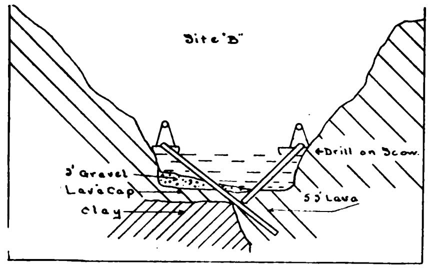
The prevailing formation of the country is volcanic, consisting of hard lava caps and boulders, cemented with volcanic ash, underlaid with clay or gravel, and full of seams, vug holes, and fissures. Time was a most essential item, as all tests must be completed and the power site chosen so that actual construction work might be gotten well under way during the low water season of 1910.

[1] San Francisco, California.

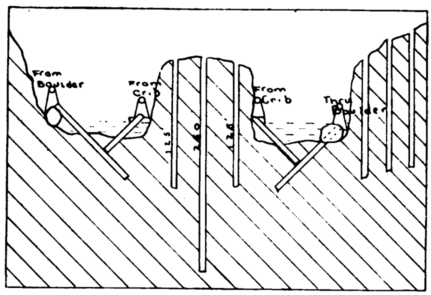
DIAMOND DRILLING ADOPTED

The first important decision which the company made regarding the work, was to use diamond core drills to thoroughly prospect the ground at each site in order to determine which would afford the best foundation materials, which required the least amount of excavation, et cetera.

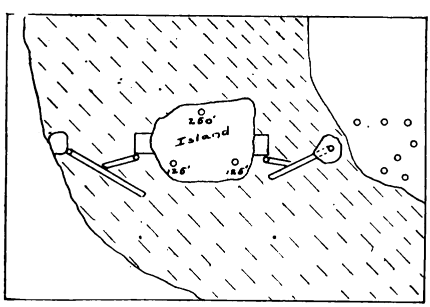
In December, 1909, the Portland Railway, Light & Power Co. let a contract to the Sullivan Machinery Company of Chicago, to do this work for them, and drilling was begun the latter part of January, 1910. Two Sullivan screw feed "Badger" drills were placed on the work in charge of one foreman, with four runners and four helpers. The drills were operated two shifts each, the day shift being sixty hours per week, and the night shift fifty-five hours per week. A drilling crew consisted of a runner and two helpers per machine.



Site B elevation.



Site "C" elevation.



Site C plan.

WORK AT "A" AND "B" SITES

It required but two holes to show that Site A was unsuitable. The formation was a decomposed volcanic ash, broken, soft and full of fissures.

The next work was done at Site B, a short distance below Site A. This proved to have some advantages as far as formation and foundation material were concerned. Disadvantages for plant location caused its abandonment, as it did not afford room for a spillway of sufficient length to keep up the required head during the low-water period, and would have necessitated the installation of flash boards at the low-water season and their removal during high water, to prevent raising the back water into the Cazadero plant above.

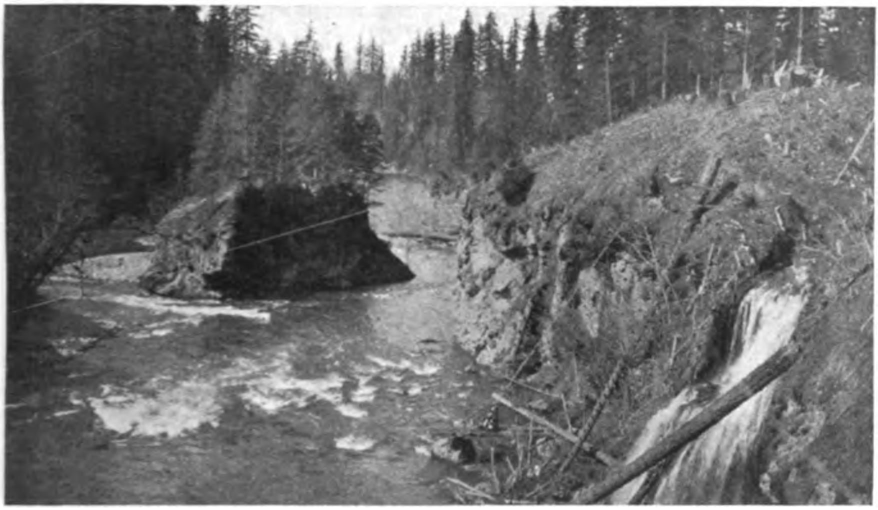
Six holes were put in at Site B. The water was about five feet deep, flowing about six miles per hour. A scow was built, floated to position, wedged from below and loaded with rock so that it would rest solidly on the cribbing. An anchor rope was also used to hold the scow in position. Two of the holes crossed each other about mid-stream, approximately 50 feet below the surface, as shown in sketch B.

In some places the formation was so soft and broken that it was impossible to use the ordinary core barrel, because the water pressure alone would cause the broken particles to press down on the working face and grind up the core. The standard core barrel was replaced with a Sullivan special double tube core barrel, such as is regularly employed in coal prospecting. This held the core properly in place, and enabled from 60 to 90 per cent to be recovered.

SITE "C" WORK

At Site C, just below Site B, an island in the middle of the River forms a natural key for the dam. Holes were drilled in both channels, on both banks and vertically through the island, as shown in the sketches, on this page. The drills, boilers and other material had to be moved from the river bank to the island by rope tramways, as the sides of the island rose in sheer cliffs at all points.

At Site C, the water was six feet deep, running about 12 miles per hour. In the left channel two holes were drilled, one from cribbing over the water and one from a large boulder on which the drill was mounted. In both instances casing



Site C, where the diamond drills found good bottom. A drill is at work near the foot of the "pole" ladder.

Hauling a boiler to the island (Site C). The side skids keep the boiler from catching on the bridge supports.

was drilled into the hole and sealed in the bed rock. In the right-hand channel two holes were also put in, the drilling being done from cribbing and from a boulder. In this case, the boulder was penetrated, and the bed rock underlying then entered.

On the river bank open pits were dug to bed rock, and in certain places, churn drill holes were sunk to the lava cap, and diamond drilling then proceeded in the

''Badger'' drill and crew on a land hole.

regular way. The drilling at Site "C" consisted of three vertical holes in the island; two holes in each channel of the river, and twenty-one holes on the river banks. These are shown in sketch C.

The moving of the drilling equipment to the island was very difficult, as all material and equipment had to be taken across on wire ropes. An extra boiler plant was necessary to supply water to the island for the drill boiler and for the drill.

SEALING POROUS GROUND

From the results of this drilling, Site C was chosen as one of the two locations for the new dams. The solidity of the rock was determined by drilling holes 35 to 50 feet deep, sealing the casing in the hole and putting 300 pounds water pressure on the hole. The porosity of the rock was then observed by the amount of water flowing into the hole. The holes were then drilled to a further depth of 70 or 80 feet and the water pressure again applied to note the increase in amount of flow. No increase of flow occurred below 40 feet in depth, indicating solid rock beyond that point.

Automatic mixing cylinders, coupled to an air compressor, will be connected to each hole and cement pumped in under 300 pounds pressure, thus filling up the interstices of the rock in both channels and preventing leakage below the dam.

SITE "D" DRILLING

When work at this location was completed, the drills were moved to Site D, about a mile and a half above the present Cazadero plant, and within a few feet of the back water from the present dam.

The surface gravel and over burden at Site D were washed off with a hydraulic giant, the stream being furnished by a four-stage centrifugal pump driven by a 200 H. P. motor, mounted on a scow in the river. A strip 50 feet wide was cleared off to the bed rock to a height of 150 feet on the bank. Two parallel rows of holes were put down, the holes being spaced 25 feet apart and the rows 40 feet apart, and staggered. Pressure determinations were made in each hole at 50 and 75 feet to ascertain the porosity of the rock.

A short piece of pipe is left sealed in the top of each hole and cement grout will be pumped into each hole under high

pressure, as at Site C. A center line of holes will then be put down between the holes already drilled. If this center line of holes does not show that the cement has been forced out all through the rock, intermediate staggered holes will be put in and cement forced in under pressure until the whole body of rock is cemented firmly together. The idea is shown in sketch D by the dotted lines around each hole, indicating the possible radius of flow of cement out into the rock.

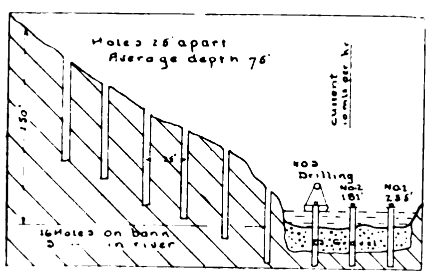
Three holes have been drilled in the river bed at Site D, the water being five feet deep and the flow ten miles per hour. At this point, drive pipe had to be put down through 23 feet of gravel and boulders. An ordinary cross chopping bit was used inside the drive pipe and where large boulders were prevalent, four to five shots of dynamite were often needed to advance the drive pipe through the gravel. This work is now being done from a scow anchored with guy ropes and wedged from the river bed. Both the drill and boiler are mounted on the scow, as shown on page 435. The three holes in the river bed at Site D averaged over 200 feet each in depth.

The power company originally tried to test the river bed at this point by sinking pits in coffer dams, but in every case these were washed out, and the work proved an entire loss. The diamond drills have proved to be the only practicable way of successfully carrying out this class of prospecting.

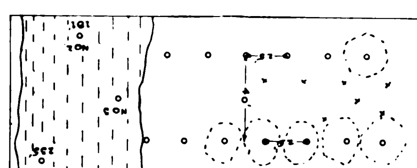
A series of staggered holes will later be drilled in the river bed for introducing the cement grout under pressure, in the manner above described, but this work will not be done until the 22 feet of gravel is excavated from the river bed. This excavation will be done with a cable and scraper. If the holes were put in now with the pipes sealed into them, these pipes, sticking up through the gravel, would seriously interfere with the excavation.

This work all comes under the supervision of Mr. Caldwell, chief engineer for the Portland Railway, Light & Power Co. Mr. T. W. Sullivan is in charge of construction at Site C, and Mr. S. C. Hulse at Site D. Mr. Eugene Whinnen had charge of the work for the Sullivan Machinery Company, and the writer is indebted to these gentlemen for data and photographs.

Sullivan diamond drill working from a scow in the river (Site D).



Site D elevation.



Site D plan.

NEW SHAFT SINKING RECORD AT CORBIN, MONTANA

By Frank J. Tuck

(In Mining and Scientific Press, September 24, 1910)

H. E. Emerson, manager for the Boston & Corbin Copper & Silver Mining Co., has achieved an enviable record for rapid shaft sinking at the company's mine at Corbin, Montana. From June 15th to August 20th, a three-compartment shaft was sunk exactly 213 feet; from the 400 foot station to a point below the 600. In other words, about 100 feet per month was made, a record for the district. It is doubtful if a three-compartment shaft of equal size, and under similar conditions, has ever been sunk so rapidly and at the same time so cheaply. The actual total cost for power, labor, timber, and supplies was only $40.95 per foot, and this included a handsome profit check to the men who did the work on contract.

The rock through which the shaft was sunk was a dark hornblende granite, commonly known as Butte granite. The rock section of the shaft measured about 17 by 7 feet, each compartment being 4 by 4½ feet in the clear. For wall plates and end pieces 10 by 10-inch timbers were used, the dividers being 8 by 10. The sets were spaced 5 feet center to center. Only one compartment was employed for sinking; a second being used for hoisting rock from the two upper development levels; and the third as a pipe and ladderway. A double-drum electric geared hoist, of Wellman-Seaver-Morgan type, with a 100 horsepower Crocker-Wheeler motor handled the cages in both compartments very satisfactorily. A straight-sided sinking bucket of about 12 cubic feet capacity was hung to the cage in the sinking compartment, and was used for hoisting water as well as broken rock. The flow of water was not excessive, about thirty-five buckets per day being hoisted.

[Air for the drills was supplied by a Sullivan 400-foot "WB2" two-stage straight line air compressor — Ed.]

Two Sullivan "UB," 2½-inch machines, with air at 80 pounds pressure, were used, and from 18 to 25 holes were drilled per round. This included 6 cut-holes which were blasted previous to the others. The holes were from 5 to 7 feet deep, usually averaging about 6 feet. The firing was done by caps and waterproof fuse, and there was no trouble with the electric hoist when hoisting men before blasting. Forty per cent gelatine dynamite was used, and with a regular charge, the ordinary 10 by 10 blasting timbers afforded satisfactory protection to the lower sets. It is doubtful if this would have been the case if batteries had been used for firing. Station sets were put in at the 500 and 600-foot levels.

The contract for sinking the shaft was awarded to three miners who agreed to furnish their own supplies and do the drilling, blasting, shoveling, and timbering. Each of these miners took charge of an eight-hour shift and had three other shaft men working with him. Co-operation and hard work seem to have been the key-note of their success. No miners ever worked with more vim, intelligence, and enthusiasm. The timbering was perfect, the whole 213 feet being exactly plumb. While the men were paid $4 per day for their labor, their profit check netted them a snug sum, and there is no doubt that the company was given handsome returns.

The cost per foot of shaft was as follows:

Labor, cost per foot	$32.76
Lumber, per foot	4.58
Supplies, powder, caps, fuse, candles	2.04
Power	1.57
Total.....................	$40.95

Besides the power and timber, the company furnished top-men, engineers, blacksmiths, and carpenters.

NOTES ON THE IMPERIAL COPPER COMPANY

By F. C. Baxter[1]

The mines of the Imperial Copper Company are located at Silverbell, in the northern portion of Pima County, Arizona. Silverbell lies approximately 35 miles north of west from Tucson, and 20 miles from the main line of The Southern Pacific Railway. It is connected with the latter by a standard gauge railroad, the Arizona Southern, owned and operated by the mining company, but as a common carrier.

At Sasco, eight miles from Red Rock, the railroad junction point, is the smelting plant of the Southern Arizona Smelting Company, also controlled by the Imperial Copper Company. This plant handles about 800 tons of ore per day from the company's mines.

Sasco and Red Rock have about the same elevation, thus giving an easy haul for smelter supplies from the main line. Sasco was chosen for the smelter site, on account of its excellent water supply. Silverbell is a thousand feet higher, and the railroad makes two switchbacks before entering the camp itself. A down-hill haul for the ore is thus provided.

Actual work was started by the Imperial Copper Company in 1902, although previous to this time several attempts had been made to operate these properties, all of which ended in failure or were but partly successful, on account of the absence of proper transportation facilities.

The present mining operations are carried on from five shafts, the Union, the Mammoth and the Billy being vertical, while the Mammoth incline of 45 degrees, and the Enterprise incline of 75 degrees are on the Mammoth and Union groups respectively.

The Mammoth incline has reached a vertical depth of 900 feet, while the Enterprise, which is just being retimbered after a fire, is 450 feet deep. The total length of the underground workings, including shafts, drifts and cross-cuts, approximates 20 miles, including the earlier workings.

The ores consist principally of chalcopyrite in the Mammoth, occurring in large, irregular bodies, lying practically flat. Copper bearing pyrite with chalcocite and chalcopyrite comprise the ores worked in the Union and Billy veins. The contact zones are so dense that they carry sufficient values to be mined commercially, even at the surface.

POWER PLANT

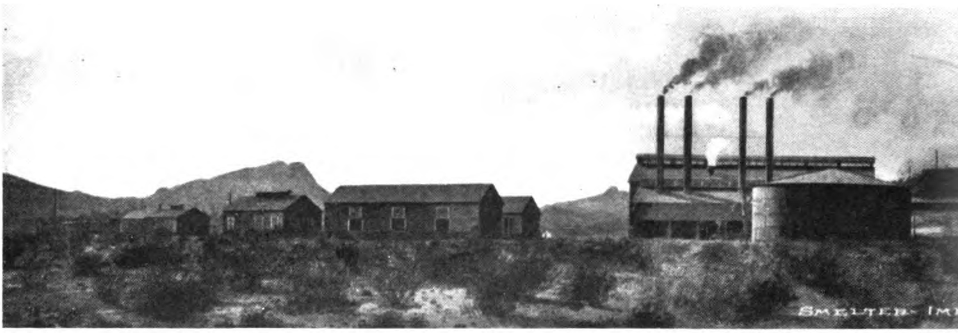
Power for mining purposes is furnished by return tubular boilers, burning California crude oil, and using mine water, which before entering the boilers is passed through a water softener. This latter device was installed about two years ago and has greatly reduced the boiler troubles formerly due to the formation of boiler scale. Compressed air is supplied to the drills by a cross compound Corliss air compressor of 3000 cubic feet capacity, running condensing, and furnishing 85 pounds of air at the compressor.

The miners are all Mexicans, the shift and "jigger" bosses being Americans. The Mexican labor at Silverbell is better than the average, as the men are well paid and as a result are less migratory than is usually the case.

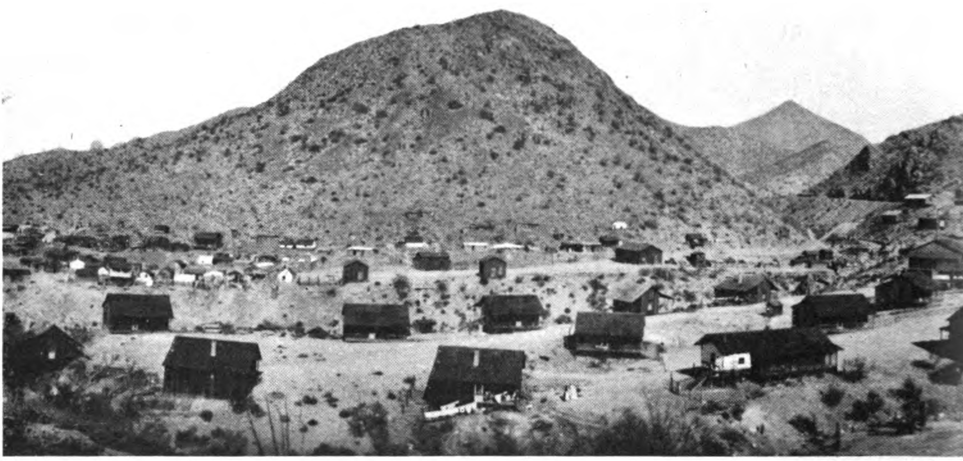
MINING METHODS

Stoping is all done by the square set system, and air feed hammer drills are used for drilling all holes that have an inclination of more than 45 degrees above the horizontal. All drifting, sinking and stoping, other than that mentioned, is performed with Sullivan "US" 2¼-inch piston drills, which have proved, after numerous competitive tests, to be the

[1] San Francisco, California.



Smelting plant of the Imper



Camp of Silverbell, Arizona. Th

most satisfactory in every way. The upkeep cost of these drills is particularly low. There are about 120 "US" piston machines in use at the present time. All machines are operated by one man each, for both drifting and stoping.

All shafts were sunk with these 2¼-inch drills, and in the Enterprise incline, the most recent opening, two drills averaged 150 feet per month, carrying the shaft 6 x 8½ feet inside the timbers, In this case, and in all shaft sinking, three men were employed, two runners and a helper.

One man, using one "US" drill, will average 40 to 50 feet of hole per shift, putting in holes from four to six feet deep, and breaks 125 to 130 lineal feet per month in the ordinary size drift.

i Copper Co. at Sasco, Arizona.

:Mines are behind the hill in the center.

Of the 800 tons of ore sent to the smelter daily, 500 tons are supplied from the Union, 250 tons from the Mammoth and the remaining 150 tons from the Billy shaft.

The ore from the Mammoth is trammed from the mine ore bins a distance of 3000 feet, to the railroad ore bins, by compressed air locomotives. These locomotives are charged to 800 pounds pressure, the pressure being reduced to 140 pounds before entering the cylinders. One charge of the tank is sufficient to haul sixteen loaded cars, of three tons each, to the railroad bins, and to make the return trip.

The compressor for supplying air to the locomotive is of the three-stage

Sullivan "U S" rock drills in an Arizona stope.

straight line type, belt driven by a 40-horse-power motor which takes its current from a high tension power line coming from Sasco. This line also furnishes power for lighting purposes.

The writer is indebted to Mr. G. W. Dietz, Auditor, Mr. Chas. Blethen, Master Mechanic, and Mr. David Morgan, Mine Superintendent, for many courtesies in the past, and at the time this article was written.

MARBLE QUARRYING IN ARIZONA

(Special Correspondence)

We believe that the knowledge of the existence of large and valuable marble deposits in Arizona will come as a surprise to many people; but, located in the Chiricahua Mountains in Cochise county, in the southeastern corner of the state, is one of the largest deposits of marble in the country. This deposit has been traced definitely over a distance of approximately 15 miles, and prospect workings made at various points over the deposit show the marble to be of a high grade throughout.

Active work is now being carried on by the Arizona Marble Company, a close corporation, composed of Denver capitalists, and under the active management of Mr. John G. Kerr, well known in marble circles. This company owns eleven claims, totalling 1760 acres, along the strike of the deposit, and has already opened them up to a considerable extent.

The Arizona Marble Co. has been in existence since January, 1909. The preliminary work necessary to actual quarrying operations has been completed. The deposit now being worked is 14 miles from Olga Station, the shipping point (eight miles from Bowie), on the Southern Pacific Railway, and the last

A corner in the Arizona Marble Co.'s quarry.

three miles of this distance are in the mountains. A splendid road for haulage has been built. A 110-horse power traction engine was used for hauling the machinery from the railway to the quarries, and now hauls the blocks from the quarry to the shipping point. The usual load from the quarry to the station is sixty tons. The traction engine has proved very satisfactory, but the intention is to ultimately install electric haulage, and the road through the mountains was laid out and constructed so that there should be but very little special work to do later, when electric haulage should be adopted.

POWER PLANT

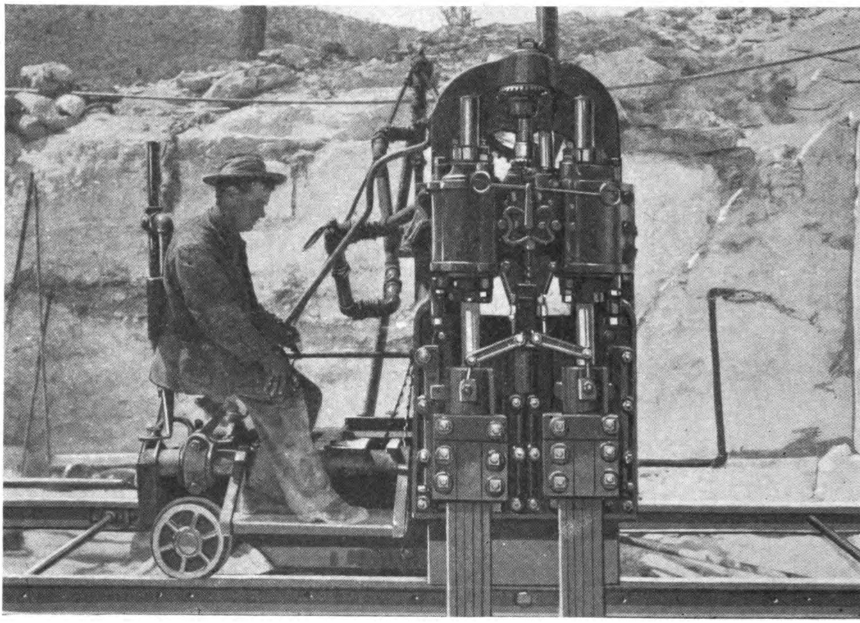
A great deal of thought and study was given to the power plant installation. Efficiency, economy of operation and dependability were the points most in mind. At present this consists of two 115 H. P. water tube boilers, supplying steam for driving the channelers and rock drills in the quarry, the derrick hoists, the Sullivan straight line Class "WA 3" compressor and the machinery in the experimental and testing mill.

The fuel used is wood, of which there is an abundance, cut from the company's own land.

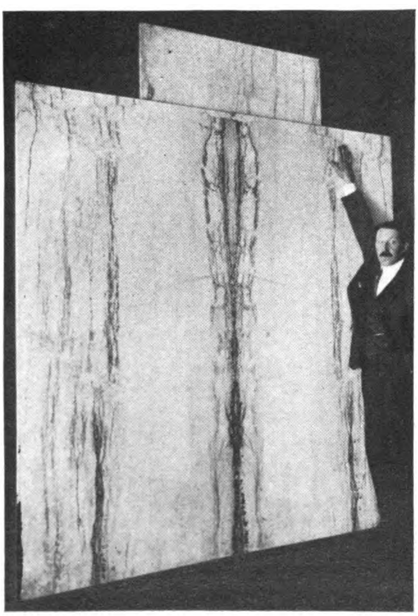
QUARRY MACHINERY

Sullivan rock drills and channelers are used in the quarry operations; the latest addition to this portion of the equipment has been one of the new Sullivan duplex channelers, type "VW." A view of this machine in operation on the quarry floor is shown by the photograph (page 442.)

Compressed air is used for driving the Sullivan Class "DB-15" and "DB-19" hammer drills, used for "plug and feather" and "foot-hole" work. Very satisfactory results are being obtained in



Sullivan duplex channeler at Arizona marble quarry.



A fine panel of Arizona marble.

block-hole work for splitting up large blocks, by the use of the "DB-15" hammer tool. By its use, the time required in setting up a piston drill is saved, and no difficulty is observed in keeping the holes in line, in order that the blocks may split perfectly. In splitting large blocks, where holes to an average depth of four to five feet are necessary, the average drilling speed is 20 feet per hour. The air pressure maintained will average 100 pounds at the receiver.

The marble is strong and solid, and is quarried in very large blocks. An idea of the size of the blocks is given in the photograph of a corner of the storage yard, page 443.

Two derricks are in operation, one 30-ton and one 50-ton. To carry out the idea of centralizing the machinery as much as possible, the derrick hoists are located at the central plant, and one engine is used for driving both hoists.

The mill is equipped with a steel frame gang saw, a rubbing bed of the underneath geared type, and a finishing and polishing table. The mill is designed for, and intended to be used for experimental work, and might be called a testing laboratory, but at the same time it will enable the company to handle and make use of many blocks which would otherwise go to waste.

The marble now being worked is white, with pronounced dark veinings, and a predominating flesh tint. A peculiarity of this marble is the absence of any weakness in the veining, being almost unique among marbles of this nature in that particular. A most excellent idea of the marble is given in the accompanying photograph. The panels (page 442) showing the vertical veinings are 8 feet and 9 feet 6 inches in height respectively. Chemical analysis shows the marble to contain 99.98 per cent calcium carbonate, a degree of purity which is very rare. The stone has a crushing strength of 12,000 pounds to the square inch. The rate of absorption is practically nil, being .00010.

At the present time the quarries are busy getting out material for the various jobs on hand. Among the more prominent buildings in which the Arizona marble is being used are: The First National Bank Building, Denver, Colo., and the bank buildings at Champaign, Ill., and Missoula, Montana.

Blocks in the storage yard.

A large quantity of marble blocks is being stored in the quarry yard ready for immediate shipment, in sizes up to 12 feet in length and containing 200 cubic feet.

STOPING DRILL STEELS

SUGGESTIONS FOR THE PROPER SHAPE AND TEMPER OF BITS

It is essential to the most efficient results in stoping with hammer drills, that everything about the machine itself be kept in the best possible condition. It is just as essential that the drill bits be properly formed, sharpened and tempered for the work to be done, and that an abundance of sharp steel of the right gauges be constantly available. Poor blacksmithing and the use of wrongly shaped steels or those whose gauge is worn down, will cut down drilling speed and waste air power and labor to a surprising degree.

The following suggestions for the use and care of stoping drill bits are reprinted from a circular of instructions sent out with each Sullivan "DA 21" Drill.

The form of drill steel which has been found to be the most practical for use with this machine is the one-inch heavy ribbed, cruciform solid steel. This type not only by its shape provides greater clearance for the cuttings to fall from the hole being drilled, but also provides greater bearing and wearing surface for the part which enters the bushing than steels of any other shape. The shape of the bit which will give the best results in any

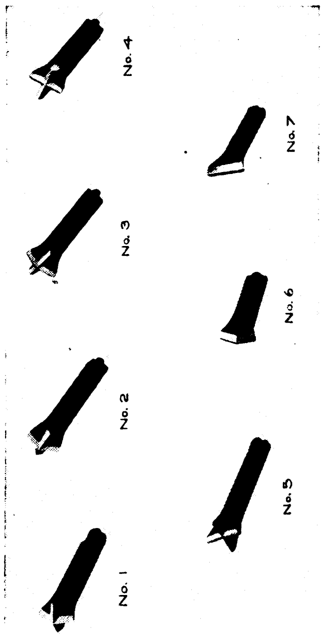


Fig. 3

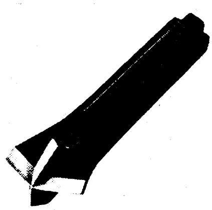


Fig. 2

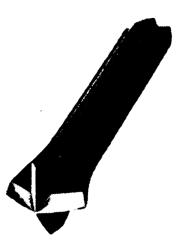


Fig. 1

particular kind of ground must be determined by experience, for a bit which proves its efficiency under certain conditions may be found inadequate in others, and a very slight change in its shape may bring about surprising results. For the foregoing reason it is impracticable to advance any hard and fast rule to follow in shaping stoping drill bits, but, as a general rule, the cross bit, illustrated by figure 1, sometimes modified to the X-shaped, as shown by figure 2, gives the best results, and such other modifications as the length and thickness of the wings, the angle of the cutting edge, the shape of the end, whether rounding, pointed or flat, may be determined only by experience in the particular kind of ground in which they are used.

The length of the wings is dependent to a great extent upon the hardness of the ground. If extremely hard, long wings are desirable, as they are capable of withstanding the blow much better than short, flaring ones; while on the other hand, short wings give the bit more clearance and enable the drill to be rotated easier for a given amount of reduction in the size of the gauge. On page 445 is a table, showing the results obtained by experiments on the seven different styles of bit shown in Fig. 3, which were operated under the same conditions, so far as consistent, in a moderately hard granite.

Under all conditions the faces or outside edges of the wings should be made flat, with square corners, and never rounding like a figure 8. This is necessary to maintain the gauge of the hole and greatly facilitates the removal of the steels if the hole is drilled at a flat angle.

Before starting, the proper steels needed to complete the hole should be picked out. It should be carefully determined just how much work each drill bit will do before the gauge begins to wear; and the operator should never try to use a bit the second time if the gauge is worn, even if it is sharp on the

cutting edge. Furthermore, a drill bit should never be used if the cutting edge is dull, for not only is the drilling speed of the machine reduced, but the cushioning effect which it otherwise gets, due to the penetration into the rock for every blow delivered, is lost, with consequent greater rebound and jar on the moving parts.

A proper gauge for each length of steel should be established and rigidly adhered to, so that the following bit will work freely in the hole. When this system of gauges has been formed, a set of corresponding templates should be made up to insure uniformity in the bits.

TEMPERING

The bits should be tempered to suit the particular character of the ground they are used in. The rear or striking end of the drill steel should also be slightly tempered and the face should be kept ground off flat with the edges slightly rounded. Do not under any circumstances insert a drill steel in the machine if the shank end is rounded or otherwise out of shape, for it will have a tendency to hollow out the striking plug with consequent breakage of this part.

SHAPES OF HAMMER DRILL BITS AND RELATIVE DRILLING SPEEDS

Description of Bit	Duration of Runs Minutes	Diam. Hole Drilled Inches	Average Depth Drilled per run 70 lbs. Pressure Inches	Average Depth Drilled per run 85 lbs. Pressure Inches	Remarks
No. 1 25 Degree Diamond Point +	2	1⅝	6⅝	8½	Spots easily. Hole rifles slightly. Rotation easy. Gauge does not wear rapidly.
No. 2 25 Degree Diamond Point X	2	1⅝	6	7¾	Spots easily. Drills round hole. Rotation easy. Gauge fairly durable.
No. 3 Convex +	2	1⅝	6⅛	8¼	Spots easily. Hole rifles slightly. Rotation easy. Gauge does not wear rapidly.
No. 4 Flat +	2	1⅝	6	7½	Difficult to spot hole. Hole rifles badly. Rotation hard. Gauge fairly durable.
No. 5 4 Degree Concave +	2	1⅝	5¾	8¼	Difficult to spot hole. Hole rifles badly. Rotation hard. Gauge fairly durable.
No 6. 25 Degree Pointed Bull—ᒧ	2	1⅝	5¾	7	Spots easily. Drills round hole. Rotation easy. Gauge wears rapidly.
No. 7 Flat Bull —	2	1⅝	5 15/16	7¼	Difficult to spot hole. Hole rifles badly (3 flutes). Rotation hard. Gauge wears rapidly.

RECENT DEVELOPMENTS IN THE UNDERCUTTING OF COAL BY MACHINERY [1]

EXTRACTS FROM AN ARTICLE BY EDWARD W. PARKER, WASHINGTON, D. C.

(Transactions of the American Institute of Mining Engineers. Canal Zone Meeting, November, 1910.)[2]

At the Seventy-sixth meeting of the Institute, held in New York, N. Y., February, 1899, I presented a paper on this subject entitled, Coal-Cutting Machinery, which has become somewhat out of date, in view of the decade's development in this feature of the coal-mining industry. It should be explained that the present paper is limited to the use of mining machines in bituminous mines. Practically all of the anthracite mined is "shot from the solid," no undercutting being done. Anthracite-mining is therefore not considered in the statistics or other references.

The statistical record as compiled by the United States Geological Survey shows that in 1898, the year preceding the presentation of my former paper, there were 32,413,144 short tons of coal undercut by the use of machines. In 1907 the machine-mined coal-product amounted to 138,547,823 short tons. In sympathy with the general decrease in coal-production during 1908, the output of machine-mined coal decreased to 123,183,334 short tons, but the proportion of machine-mined coal to the total output, nevertheless, showed an increase from 35.1 per cent in 1907 to 37 per cent in 1908. In 1898 only 19.5 per cent of the total product was undercut by the use of machines. The number of undercutting-machines in use in the bituminous mines of the United States has increased from 2,622 in 1898 to 11,144 in 1907, and to 11,569 in 1908. The total production of bituminous coal in the United States in 1908 was almost exactly double that of 1898, while the machine-mined portion of the product of 1908 was nearly four times that of 1898. These figures give an idea of the growth in the mechanical production of bituminous coal. It is unfortunate that we have no exact information in regard to the quantity of pick-mined coal produced. It is not sufficient to say that the difference between the total production and that reported as mined by machines represents the pick mined tonnage, since there would be included in this difference a much too large quantity of coal mined principally by the use of powder. And right here is one of the most serious problems with which the bituminous-coal operators of the United States are confronted at the present time. The undercutting of coal by hand with a pick is an exacting kind of labor and the miner may not be blamed for a disinclination to lie for 5 or 6 hours on his side making a cut of from 4 to 5 feet deep in the coal. When, however, conditions are such that the mechanical cutting of the coal is impossible, no other considerations should permit the miner to neglect his duty.

There has been in the bituminous regions a growing tendency to shoot the coal "from the solid," which consists of "making the powder do the work," a practice which cannot be too vigorously condemned. It is bad for many reasons, the least of which is the profligate waste arising from the excess of slack or fine coal produced, a product which is frequently unsalable, or, unless suitable for the manufacture of coke, must be sold at less than the cost of production. Moreover, it is pre-eminently anti-conservational. Far worse than this is the increase of the natural hazards to which the mining of coal is subject. To all familiar with bituminous-coal mining, it is well known that when "the powder does the work" the tendency to "windy" or "blown-out" shots is markedly increased and that these are prolific causes of the

[1] Published by permission of the Director of the U. S. Geological Survey.

[2] Trans., xxix, 405 to 459 (1899).

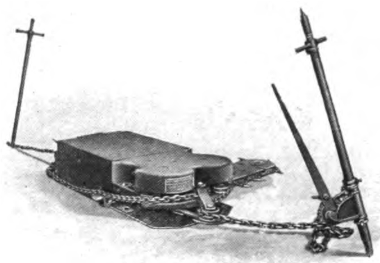
Sullivan pick machine.

dust-explosions which so often fill with horror the readers of the daily press. Few of the reading public realize, however, that a far larger aggregate of deaths in the coal-mines is due to the falls of slate and coal, and that these are indirectly due to the same originating cause. In 1907, the darkest year in the history of coal-mining in the United States, so far as the number of lives sacrificed goes, there were 947 men killed in gas and dust-explosions, with 343 injured while the falls of coal and roof killed 1,122 and injured 2,141. In 1908 explosions killed 396 and injured 326, and falls of coal and roof killed 1,080 and injured 2,591. The figures are significant, but it is hard to make the miner see that the weakening of the roof and the fracture of the ribs by the excessive use of powder in his work are responsible for the falls which make the long lists of casualties every year. Mining engineers know it, but it is a hard thing to prove it to the miner, or if he, too, knows it, he still assumes the risk. The public attention is not called to it in the same way that the horrors of explosions are heralded, for these accidents from falls, which usually occur singly, do not figure in the press-dispatches, and are not known outside of the community in which they occur.

A contributing factor, which has for one of its results the continuation and the extension of this reprehensible practice of shooting from the solid, is the custom in some coal-mining districts of paying for the mining of the coal on the mine-run basis. Where such custom obtains there is no incentive to the miner to produce a merchantable grade of coal. He is paid as much for slack as for good coal, and when "the powder does the work," what's the odds? In one state, Oklahoma, this pernicious influence has been so highly developed that by act of legislature the operators are compelled to pay for the mining of coal on the mine-run basis. Can any one imagine that the legislators of that state realize to what an extent they have made themselves responsible for the accidents that are sure to occur? And I am credibly informed that there is strong likelihood of no less a bituminous-coal producing state than Pennsylvania writing a similar law upon its statute-books. Of what use, may we well ask, to establish mine-rescue stations, unless to recover the dead bodies, if law-makers show such ignorance of the conditions which make toward the saving of life and limb, the protection of property, and the conservation of the coal. The coal-miner is one man who has to be protected not only against himself, but more particularly from the harmful activities of his would-be friends.

Let me give one illustration of the evil effects on the coal itself of paying the

Sullivan electric chain coal mining machine.



Sullivan air longwall machine.

miner on the basis of run-of-mine coal. One of the large operators in the interior region has furnished me a statement that shows some striking comparisons. The company operates in several states, and its production each year exceeds 1,000,000 tons. The mine-run basis was put into effect on May 30, 1900. The records kept by the company show that from 1894 to 1900 the proportion of slack was 27.8 per cent of the total output; from 1901 to 1905, with mining on the mine-run basis, the percentage of slack was 36, varying from 32 per cent. in 1901 to 38.15 per cent. in 1904. Since 1905 the company has made an agreement with the railroads by which the latter accept, as lump-coal, the mine-run product with 25 per cent. of slack screened out. This arrangement has apparently reduced the percentage of slack, but still, from June 1, 1905, to May 31, 1909, the screenings have equaled 32.36 per cent of the total production.

It is a self-evident proposition that the payment for this waste must eventually fall as well upon the miner as upon the operator and the consumer.

As the sewing-machine has supplanted "the bright little needle, the swift-flying needle, the needle directed by beauty and art," and the machine reaper has taken the place of the hand-swung cradle on the farm, so has the coal-mining machine ameliorated to a marked degree the labor-conditions in the coal-mines. A production by the use of undercutting-machinery of 138,500,000 tons, or 37 per cent. of the total output of bituminous coal, is significant. A portion, and probably a large portion, of this large quantity, had it not been undercut by machines, would certainly have been shot from the solid; and every ton of gain in machine-mined coal is that much more for better coal and greater safety for the mines and the mine-workers, notwithstanding the fact that the operation of the machines themselves is occasionally responsible for some of the casualties. The mine inspectors' reports contain statements of the men killed and injured by the mining-machines, but these do not and cannot subject to risk the hundreds of other employees, as is done every time a shot is fired from the solid.

While the anthracite mines of Pennsylvania are not liable to the same danger of dust-explosions as are the bituminous mines, the excessive use of powder by the miners, about 30 years ago, became a serious question, because of its effect upon the coal and upon the roof and pillars; and in order to minimize the evil, the operators, by agreement with the miners, increased the price of powder to a figure which made it an incentive for the miner to exercise economy in its use. The increase in the price of powder was compensated to the miner by an increase in wage. Nearly 25 years later, when the manner in which the adjustment had been made had passed out of memory, the "extortion" practiced by the operators became the subject of somewhat acrimonious discussion, and in order to settle the difficulty the practice was abandoned, whether wisely or unwisely I am not prepared to say.

In the mining of bituminous coal, proper regard for safety, and the securing of the maximum quantity of marketable coal, require that the minimum amount of powder necessary to bring down the coal should be used. This establishes as a pre-requisite that the coal should be

properly undercut and sheared. There are, of course, some mines in which the physical conditions militate against the introduction of mining machines, but these are comparatively rare.

A recent development in mechanical coal-cutting has been the design of a machine adapted to use in steeply dipping beds as well as those in which the inclination is slight. The machine is described in detail later in this paper. But whatever the physical conditions, the coal should be undercut, and no excuse for failure so to do should be accepted. At the present time the only mines in which the installation of mining machines is impracticable are those of comparatively small production, and of a capitalization and market-conditions which do not permit the necessary expénse. These mines, however, are becoming fewer each year. The tendency in coal-mining, as in other lines of industry, is towards the large unit, for it is only in the operation of large units that effective economy in production and in the marketing of the product can be secured. The average production of the bituminous coal mines in the United States in which undercutting machines were employed, in 1908, was 94,177 short tons. Exclusive of the purely local banks, whose output in no case exceeded 1,000 short tons, the average production from mines in which machines were not used was 45,281 short tons, and including the output of local banks, this average is reduced to 29,442 short tons. It is claimed that many more machines would be used and that a much larger machine-mined output would be mined but for the differential in wages made against the machine-mined coal. This, it is averred, takes from the operator the earning capacity of the capital invested in the installation, and limits the advantage secured by him to the larger proportion of lump coal obtained by having his coal undercut.

Sullivan post puncher for steep veins.

The two general types of undercutting machines most in use at the present time, as 10 years ago, are the pick, or puncher, and the chain-breast machine, although some long-wall machines are in use in the thinner beds, principally in the interior states. Long-wall mining is not practiced in the United States to the same extent as in Europe, nor to the extent it should be.

In 1908, of the 11,569 machines in use, 6,380 were of the pick, or puncher, type, 4,992 were of the chain-breast pattern, and 197 were long-wall

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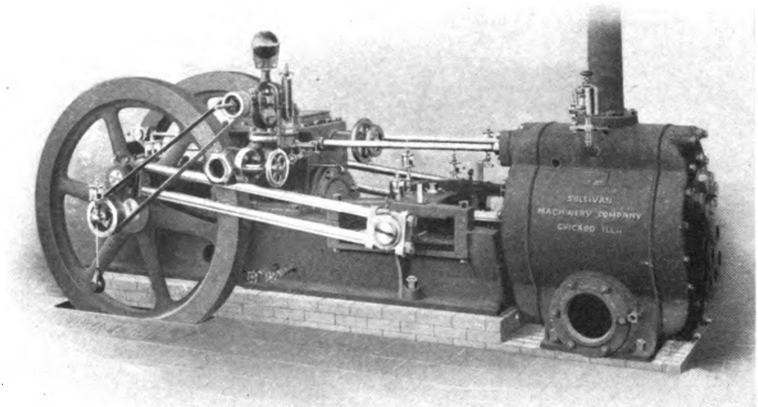
ATOMIZING FUEL OIL WITH AIR

By R. E. Ellis[1]

Manufacturing industries in various parts of the country have long depended on natural gas for a cheap and convenient fuel. The supply of gas in some localities has fallen off materially in the past few years, and it has been necessary for the industries affected to change their furnaces and use coal, at a much higher cost, or to find some other fuel similar to gas in economy and application. Such a fuel is at hand in the shape of crude oil,

[1] Chicago, Illinois.



Sullivan "WA" air compressor, for low air pressures.

which has been produced recently in greatly increased quantities.

Oil has, of course been used as fuel for years, but as a substitute for natural gas, its application has lately received more than ordinary attention, resulting in many improvements in the methods of its use.

It has been the writer's privilege, during the past year, to observe some successful experiments along this line, and these notes have been prepared with the thought that the results obtained may be of interest to other engineers as well.

In order to burn oil under boilers, it must be injected under pressure as a spray or gas, the latter being considered to permit the most thorough combustion. Steam and air are both employed to atomize the oil, special burners being provided, with a double or annular nozzle, through which the oil and air or steam are simultaneously discharged.

A heater, placed on the oil supply pipe, raises the temperature of the oil to about 200 degrees Fahrenheit before it reaches the burner. Of the two atomizing media, air has proved to be much more satisfactory and more economical than steam. It saves fuel, because it is constantly dry, whereas steam is frequently damp, or even carries with it water of condensation. It is also possible to maintain an even pressure and temperature with air, both of which are difficult when steam is employed.

Opinions vary as to the pressure at which the air should be used. Some engineers consider from one to four pounds per square inch sufficient, while another and perhaps larger class prefer 15 to 25 pounds at the regulating valve. Of the two, the higher pressure seems to have much in its favor. Regulation of pressure is easier, and the temperature may be held more uniform. With low pressures, a very narrow margin of variation is allowable, or in other words, a slight variation in initial pressure has a greater influence on the operation of the burners than when heavier pressure is available.

It has been demonstrated that the greater first cost and additional horse power entailed by the high pressure installation, are more than compensated by the increase in efficiency.

One of the principal districts in which the use of oil has replaced that of natural gas is Eastern Kansas and northwestern

Oklahoma. The zinc and lead smelting furnaces, and the cement and terra cotta mills in this field form a group of industries requiring cheap fuel in large quantities.

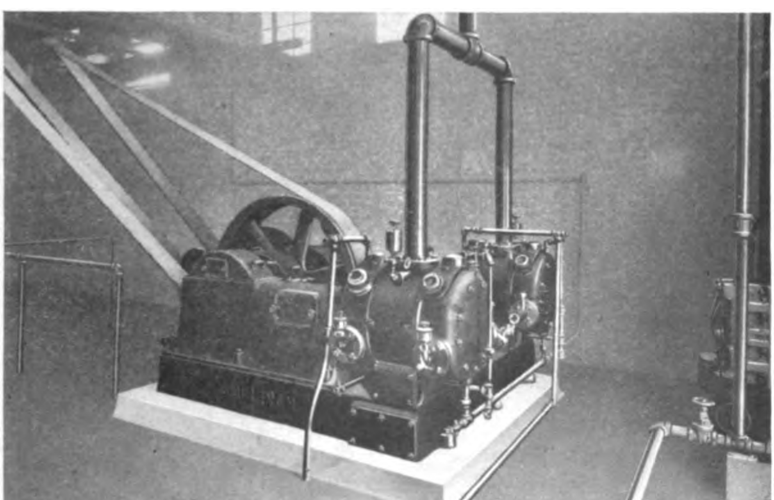
A compressor used with success for this purpose in the Kansas field is the Sullivan class "WA" machine, arranged to give a pressure of 20 pounds to the square inch. These compressors are of the straight line pattern, with a simple steam cylinder 12 inches in diameter, a 19-inch air cylinder, and a common stroke of 14 inches. They are rated for a capacity of 690 cubic feet of free air per minute at sea level, at a speed of 150 R. P. M. The steam cylinder is fitted with balanced valves, controlled by Meyer cut off gear, while the air is admitted and discharged through automatic poppet valves of an improved type. Page 451 shows one of these compressors.

LOW PRESSURE SYSTEM

In the Kansas field, about 2½ barrels of fuel oil are assumed as equal to one ton of Kansas coal, or to put it in another way, one gallon of oil is equal to about 175 cubic feet of natural gas. Oil at 65 cents per barrel represents about the same expense for fuel as gas, if sold at 7 cents per 1,000 cubic feet.

CHICAGO REDUCTION COMPANY

The Chicago Reduction Company, which treats much of the garbage and refuse produced by the city of Chicago, has for some time past employed crude oil as fuel in its rotary driers, vaporizing the oil with steam. Its engineers found that the steam did not give uniform temperatures or pressures and was not economical, because a large amount of the heat produced was consumed in vaporizing the moisture in the steam. About nine months ago, after investigating the compressed air system, a Sullivan "WI" duplex belt driven air compressor was installed compressing 496 feet of free air per minute to 40 pounds pressure. This has improved the economy and efficiency of the service to a marked degree, accomplishing a saving in fuel over the steam vaporizing system of some 20 per cent. In other words, for every 1,000 gallons of oil needed with steam, but 800 are now



Sullivan "WI" duplex motor driven compressor, in plant of Chicago Reduction Co.

needed to do the same work. The air pressure is reduced at the burners to about 30 pounds per square inch. This relatively heavy pressure is required to secure the very high temperatures necessary to drive off all the moisture from the material sent through the driers. When steam was employed at the nozzles, a sediment like tar was given off from the oil, and deposited in a coating on the floors of the ovens, showing imperfect combustion. When the air system was installed, the heat generated was so much greater that the sediment was ignited.

The oil-air system is used in nine double-burner ovens, each seven by 11 feet, and each serving a rotary drier 70 inches in diameter by 40 feet long.

A larger Sullivan machine of the same type has just replaced the first unit. This has two air cylinders, each 16 x 14 inches, compressing 1,074 cubic feet per minute, at 165 R. P. M. to 40 pounds' pressure at the receiver. The cranks, crossheads, air valve eccentrics, and other main working parts are protected from dust by a tight iron casing and are oiled automatically by the bath system. The inlet air valves are of the semi-rotary pattern, positively driven, while the air is discharged through poppet valves which open and close automatically.

Power is purchased at a very low rate from the Sanitary District power station at Lockport, to operate an alternating current motor which drives the compressor by belt. An unloading valve on the air inlet pipe of the compressor permits economy of power at times when the demand for air is reduced. The use of compressed air for atomizing fuel oil is an application of considerable importance for this form of power.

A FACE LOADING MACHINE FOR COAL MINES

(Contributed.)

The July number of Mine and Quarry contained a description of the mines and methods of the Wind Rock Coal and Coke Co. at Wind Rock, Tenn., in which occurred a reference to a coal loading machine for use at the working face. So much interest was manifested in this apparatus by readers, that the editors have secured and present below a brief description and a photograph of the loader in question.

The machine is essentially a shovel, delivering coal scooped from the floor into a conveyor at the rear, and thence into mine cars. The apparatus is mounted on a truck, runs on mine track, and is self-propelling. The various operations are performed by electricity, through sprocket chains, shafts and gearing, and are controlled by hand wheels.

The front part or jib of the machine, on which the shovel is mounted, swings laterally, as directed by the operator, covering a space 19 feet wide. The yoke supporting the shovel is provided with a vertical adjusting device, operated by a hand wheel, to adapt the shovel to the height of the track or to shovel over any irregularities in the bottom. The shovel can be raised to clear the track or lowered to shovel eight inches below the top of the rail. The shovel is 30 inches wide and handles lumps up to this size. The rear conveyor can be adjusted vertically and shifted laterally so that cars can be loaded readily on sharp curves or even on a track parallel to the loading track. This conveyor is a moving apron 24 inches wide and forms an excellent picking table to picks late before the coal goes into the car

PERFORMANCE

Since the machine was used in the Wind Rock mine, a newer model has been con-

structed, which is now in use at the U. S. Coal and Oil Company's mine at Holden, W. Va. The coal at Holden is peculiarly hard and strong, difficult to shoot down and nearly as hard to shovel as large lumps of limestone. In spite of delays and lost time, for which the machine was not to blame, it averaged 128 tons per day; the lowest day's work (due to lack of shot coal) being 90 tons and the highest 150 tons. The average time of loading and shifting a car was 8.4 minutes, or 21.3 per hour.

The territory in which the machine worked consisted of seven rooms, recently turned off the airway in No. 5 mine, corresponding to the airway off the first right entry in No. 2 mine. Much of the work was done on curves. The rooms ranged in width from 21 feet to 27 feet and all but two had two tracks. The rooms were on the butts of the coal, which greatly increased the difficulty of shooting coal down.

The crew of the machine consisted of four men, as follows: One machine runner, one man in front, and two men to handle cars and pick slate.

During six days of its operation a record was kept of all features of the run, cars loaded, time required to load and shift, time to change the machine and time lost for any cause. During the six days the machine loaded 768 tons of coal, the time of loading and shifting cars being 36 hours, six minutes; time changing the machine four hours, 21 minutes; time lost 14 hours, 33 minutes; total time 55 hours. The machine loaded out four rooms per day and part of the lost time was due to the delay in getting coal shot and waiting on smoke. Much time was lost in pulling down standing shots.

We are indebted to Messrs. Myers & Whaley, engineers and builders of these machines, of Knoxville, Tenn., for the information and photograph used in this account.

The Hamilton Manufacturing Co. of Cleveland, Ohio, also build a loading machine intended for the same purpose.

Coal loading machine at work. The front shovel is rising to dump into the rear bucket, which in turn delivers it to the conveyor.

MINE AND QVARRY

VOL. V. NO.

FEBRUARY, 1911

THE RAS OBISPO CUT, PANAMA, SULLIVAN DRILLS AT WORK.

MINING IRON UNDER THE SEA

NEW CANALS AT THE "SOO"

MACHINE MINING IN LOW COAL

PVBLISHED BY THE SVLLIVAN MACHINERY CO. 150 MICHIGAN AVE. CHICAGO.

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MINE AND QUARRY

Vol. V, No. 3 FEBRUARY, 1911

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

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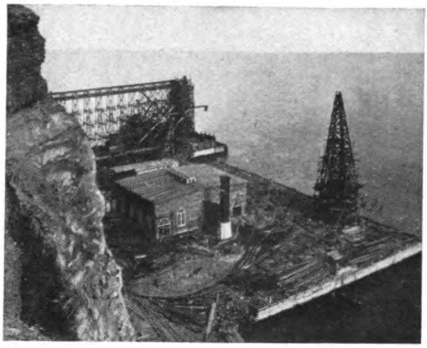
The accompanying photograph shows four sections of a diamond drill core recently secured in drilling for limestone near Auburn, California, by the Mountain Quarries Co. The average length of the cores is nine feet four inches, and their diameter, 15/16 of an inch. They were removed with a Sullivan "Class H" diamond drill, using a ten foot core barrel. The cores, it will be noted, form a perfect record of the rock formation from which they were cut.

The Report of the Pennsylvania Department of Mines, for 1909, by James E. Roderick, its Chief, has just been published. It shows a total bituminous production of 136,205,695 tons, of which 56.03 per cent was mined by hand, and 43.97 per cent by machine. Since 1901, the percentage of the total product mined by machine has increased 7.77 per cent, but the total has increased nearly 60 per cent, so that the machine tonnage is much more impressive than it appears at first. The total number of machines used in the State in 1909 was 5,372, of which 1,929 were operated by electricity and 3,443 by compressed air.

The proportion of electric chain machines is gradually increasing, and the tonnage cut by them is greater than that cut by air machines or "Punchers." In 1909, 28,832,604 tons were mined by air driven machines, and 31,052,959 by electric chain types; or 21.17 per cent as against 22.80 per cent of the entire production of the state.

The State Department of Mines of West Virginia is taking drastic measures to put a stop to the practice of shooting from the solid. Twenty miners were arrested one day recently in the southern part of the state charged with this offense, and had to pay fines ranging from $10 to $17 each. A mine foreman who connived at the violation of the law was fined $50. —*Engineering and Mining Journal*, Nov. 26, 1910.

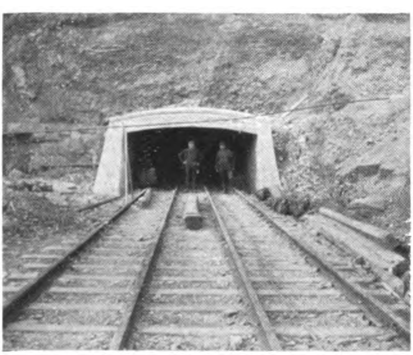
Diamond Drill Cores



Scotia pier and power plant

Ore chute to the pier

Tramway to the shipping pier



Entrance to submarine slope

Head buildings at the slope

MINING IRON UNDER THE SEA

PREPARED FOR "MINE AND QUARRY" BY H. W. BUKER*

In Conception Bay, on the eastern coast of Newfoundland, lies Bell Island, the site of the Wabana Iron Mines, which during 1910 supplied 1,250,000 tons of ore to Canadian, European, and United States ports. It has now been established that the iron which outcrops on the Island is only the fringe of great deposits which extend far under the bay. A submarine slope has been driven nearly 7,000 feet from high water mark by the Nova Scotia Steel and Coal Company, and has shown that the ore improves in quality and thickness as it gets deeper. It is largely because of the proximity of these deposits to the coal fields of Cape Breton that the steel industry of Eastern Canada has grown to its present proportions, and the ore reserves which have now been proved to exist under the ocean, insure the prosperity of that industry for centuries to come. It is only forty years since accident revealed the presence of the ore deposits, and not until 1893 was any attempt made to explore or develop them. Investigation was begun at that time by the Nova Scotia Steel and Coal Company, Limited, which resulted in the lease of the deposit and its eventual purchase.

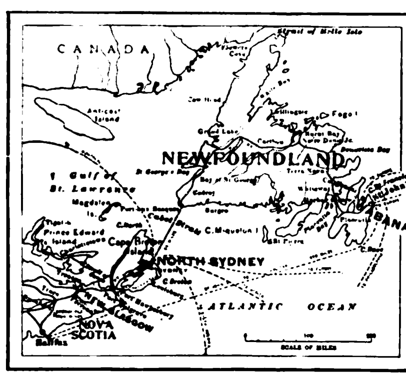
The north side of Bell Island contains a number of seams of red hematite iron ore, running from 50 to 55 per cent in iron, three only of which are economically important at present. These seams or beds are interstratified with the sandstone and shales of the formation, with a common dip and strike, the former being about eight degrees.

EARLY DEVELOPMENT

The work of the Company, begun in 1895, at first was only open-cut mining, the earth covering being stripped and the ore then carried by an endless rope tramway to a pier on the south side of the island. This pier was a block set out some distance from the shore and connected with it by a suspension bridge; a trestle work was built to it later.

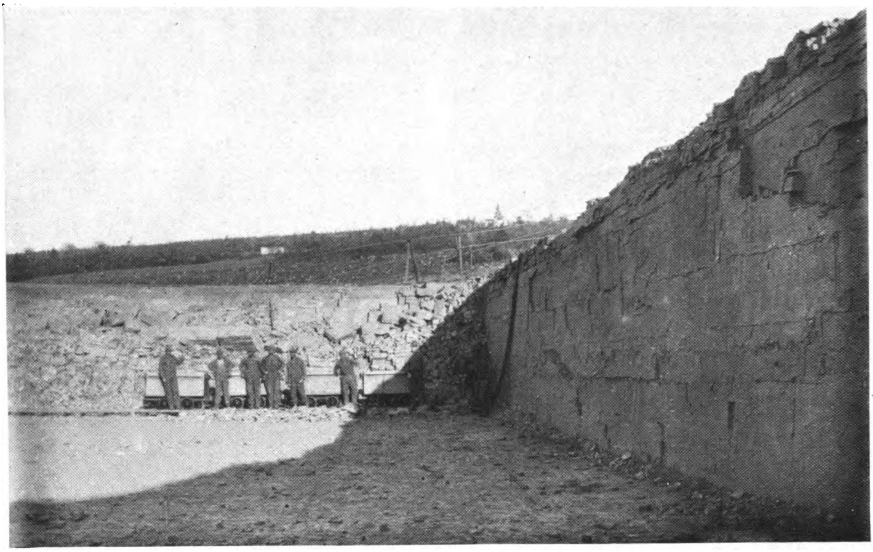
At first the ore was used solely to supply the blast furnace of the Nova Scotia Steel Company at Ferrona, but in 1899 the Dominion Iron and Steel Company commenced operations at Wabana. This company purchased from the Scotia the lowest of the three parallel beds of ore which the latter had been operating, together with all their equipment. The Scotia Company at once commenced to open up the middle, or Scotia, bed of ore in order to secure an uninterrupted supply. Twelve hundred men were kept at work that season, mining from the old property and developing the new, and when the time came for them to turn the Dominion property over, the Scotia bed was ready to produce all the ore required. Tramways had been constructed, a new pier built, and the Scotia went ahead producing ore without a break in deliveries.

The Dominion Company secured the upper and lower of the three beds of ore and a block of submarine areas adjoining the shore and containing about three square miles. The land ore beds of the two concerns overlap, one company work-



Newfoundland, showing location of Wabana

*Rockland, Maine.



Open cut mining in the lower bed

ing in some cases directly underneath the other, but in the submarine areas each company owns all the ore in its holdings.

When building their new pier, the Scotia Company took advantage of a great gulch near it to construct an immense storage pocket of ore. By very little work, this break was converted into a storage receptacle of much greater capacity than the one formerly used.

THE SCOTIA BED

For two years the Scotia bed was "stripped," but in 1902 two slopes were begun. Work was carried on rapidly, and within a year these mines had been opened up and were being worked by the room-and-pillar method. Both slopes were sunk at a considerable height above tide-water, and one was driven out on the shore above high-water mark, forming an adit. The slopes are carried from eight to ten feet in height, and 17 to 20 feet wide, in two sections, a 14-foot heading, and a side slice six feet wide. The sketch on page 457 indicates the method of drilling the holes in 8-foot ore. Another line of holes is put in when the ore is ten feet high. The center cut holes are about seven feet deep, and the rib holes six feet. All holes are bottomed with a diameter of 1⅝ inches, and 1½ inch 50 per cent dynamite is used for blasting.

The view of the drill at work underground, page 458, and the picture of open cut mining, shown above, indicate the marked vertical, or rhombohedral, cleavage of the deposit. This "blocky" ground causes trouble in drilling uppers, since the hole has a constant tendency to run out of line, requiring frequent changes in the position of the drill on the column. There is just enough moisture in the ore to make the cuttings ball up and pack behind the bit. The wet or down holes, however, are fairly easy to drill. Sullivan "UD" (3-inch) differential valve piston drills are used exclusively by the Scotia Company, and fifty are now in operation. The Dominion Iron and Steel Company employ forty Sullivan drills, including a few "UE2" (3⅛-inch") machines.

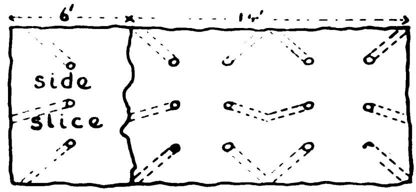
In the Scotia vein the drills are mounted on single screw columns without arms, but in the submarine slope and in the 14-foot bed of the Dominion Company, the double screw column with arm is preferred. Tripods are used in open cut work, and in driving raises or break-throughs underground.

Air pressure for the drills is 80 pounds at the receivers, but at the ore faces is actually about 70 pounds, and in the submarine slope, now between 7,000 and 8,000 feet in length, the pressure falls to 60 pounds at the face.

BONUS SYSTEM

A runner of average ability puts in about 75 feet of holes per nine-hour shift with the "UD" drill. Good men have run up to 100 feet or more per shift. An interesting bonus system is employed by the Scotia Company, and since it was established, in 1904, the efficiency of the drilling work has been materially increased. An account of this system was furnished "*Engineering Contracting*" in 1906 by Mr. A. R. Chambers, and reprinted in Mine and Quarry for November of that year. The following is quoted to show the results of the scheme.

"Comparing the drill sheet for October, 1904, with that for August, 1905, we see that each drill averaged 58.6 feet per day in October, 1904, as compared with 69 feet in August, 1905. This is an increase of nearly 18 per cent, but, excellent as this increase is, it is not so striking as the increase in the number of tons of ore broken down by each drill. In October, 1904, each drill averaged 26.2 tons per day; while in August, 1905, each drill averaged 44.5 tons per day — an increase of nearly 70 per cent. We note also that this remarkable increase in output was not obtained at the expense of more dynamite; for, in the 1904 sheet oniy 0.64 tons of ore were broken per pound of dynamite, as compared with 1.2 tons per pound in 1905." With reference to the



Plan of drill holes in room mining

decreased amount of dynamite per ton of ore, Mr. Chambers says that this has been brought about by requiring the drillers to pay more attention to placing the holes as accurately as possible — to give the dynamite the best leverage; that is, cut holes to meet within about twenty inches, and not overburdening side-holes. "It is," he says, "also partly due to the fact that, whereas we used to run the drift eighteen feet wide, with twelve holes, we now run it about fifteen feet wide with twelve holes and side cut to eighteen feet wide with a couple of extra holes. The increased number of feet now drilled per day enables us to do this in the same time."

The following notes on the drill work in 1909 may prove of interest:

No. 1 Mine

Drill days	3,458
Total feet drilled	251,521
Average feet drilled per day per drill	72.7
Output, tons (long)	149,804
Tons per foot drilled	.59
Tons per drill per day	43.3
Drill repairs	$547.66
Repairs per drill per day	.15
Repairs per foot drilled	.0021

No. 2 Mine

Drill days	4,739
Total feet drilled	323,337
Feet drilled per day	68.2
Output	207,025.6
Tons per foot drilled	.64
Tons per drill per day	43.6
Drill repairs	$805.66
Repairs per drill per day	.17
Repairs per foot drilled	.0024

Sullivan "UD" Drill in No. 2 Mine. Note the blocky nature of the ore

Before being sent underground, all drills are tested to determine the force of the blow, so that an efficiency rating can be assigned each machine. The testing machine is the invention of Mr. A. R. Chambers of the Scotia Company. It consists of a Sullivan "UD" (3-inch) drill, to the piston of which the piston of the drill under test is clamped. A system of pipes and gauges shows the relative efficiency of the new drill.

All drill steel is sharpened in a drill sharpening machine whose striking parts are made up of two Sullivan "UD" drills. This and the testing machine are located in the Company's very complete machine shop, near the No. 2 mine.

THE SUBMARINE SLOPE

About 1905 the possibilities of developing the submarine areas began to attract the attention of the Scotia Company. Further additions to its underwater holdings were secured, until it owned 35 square miles of submarine areas. At the same time the Dominion Company increased

its submarine holdings until it held five square miles. The Scotia Company decided to drive a pair of slopes to the submarine areas, and, an arrangement having been entered into with the Dominion Company by which the slopes were to be driven through the areas of the latter corporation, work was commenced in May, 1906. It was known that at distances of about 250 and 1,000 feet respectively, serious faults would be encountered, so it was not considered advisable to make any expenditure for plant until these should have been passed successfully. The following description of the first 4,000 feet of this slope is abstracted from a paper presented by Messrs. R. E. and A. R. Chambers before the Canadian Mining Institute, early in 1909.

"In August the first fault was encountered. Fortunately, although this dislocation amounted to an upthrow of 29 feet with only 85 feet of strata intervening between the workings and the bottom of the ocean, the volume of water encountered was trifling.

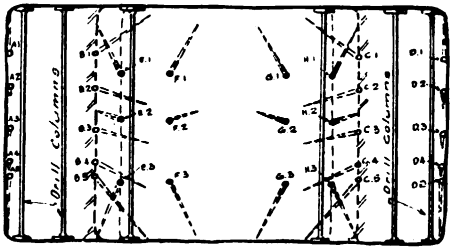
"From a study of the rock structure upon the land it was fairly evident that this upthrow would be followed by a corresponding downthrow running N.E.–S.W., after driving about 800 feet approximately at right angles to the fault first encountered. It was consequently decided to continue the slope in the strata underlying the ore in order to maintain as uniform a grade as possible. The wisdom of this course was verified by encountering the ore beyond the second fault at the distance and height expected, and of greater thickness. This fault was more serious, containing four feet of clayey decomposed rock, and an increased flow of water. The soft ground was handled by careful spiling and the water could easily be handled by two No. 6 Cameron pumps. The quantity did not exceed 50 gallons per minute.

"Beyond this second fault no serious difficulties were encountered for a further distance of 1,800 feet, at which point a downthrow fault of 26 feet was reached. The cover had increased to a total of 293 feet, and in consequence a greater feeling of security was felt in providing against any difficulties which might occur. With the increased depth, however, a corresponding increase in firmness was found and the clay encountered in previous faults was not met here. The slope was continued in the strata overlying the ore, but on an increased grade for a distance of 400 feet, when ore was again entered, having a normal thickness, and a normal dip of 12 per cent. The grade for the 400 feet was made 20 per cent, which by trimming will be subsequently reduced to 18 per cent. For this 400 feet the effects of the fault were noticed in the increased tenderness of the roof, necessitating timbers being placed skin to skin; and in the amount of water dripping from above. The total quantity of water was, however, in no way formidable.

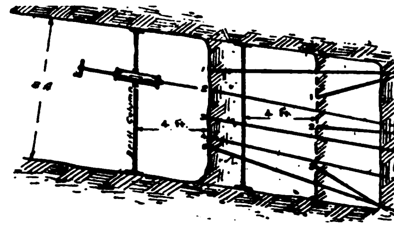
"On entering the Scotia areas at a distance of nearly 4,000 feet from the shore the conditions were as favorable as could have been hoped, and more so in that the quantity of water handled was very small compared with what was expected.

"The advances up to December, 1910, were as follows:

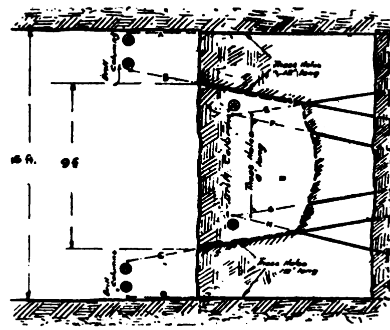
	FEET
Slope commenced May 21, 1906	
Distance driven to Dec. 31, 1906..	704.6
Distance driven to Dec. 30, 1907..	1,916.1
Distance driven to Dec. 24, 1908..	3,965.0
Distance driven to Dec. 30, 1909..	5,400.4
Distance driven to Dec. 17, 1910.. (at a depth of 1,300 feet below the surface of the ocean)	6,815.62
The month of least advance was August, 1907, in passing first fault, or....................	42.5
The month of greatest advance was November, 1908, or.......	247.81
In the 4 weeks from the 16th of Nov. to the 14th of Dec., 1910, an advance was made of.......	270.1
In week ending January 23, 1909, an advance was made of.......	74



End Elevation



Side Elevation



Plan of drill holes in Submarine Slope

"This gives a record of 11¼ feet per day for a month. This gives a record of 12 feet 1 inch per day for a week. The size of excavation for this driving was 13 to 15 feet wide by eight feet high.

"As the work proceeded it was ascertained by diamond drilling that the lower bed had increased very greatly in both thickness and richness. At the outcrop, this seam was about eleven feet thick, but it increased gradually, and after passing the faults had more than doubled, while analysis of the one showed that the iron content was much higher and the silicon correspondingly lower."

METHOD OF WORKING

Three eight hour shifts are worked. When the air is cleared of smoke from the last shot, the drillers and loaders proceed to the face. The drillers and their helpers assemble the drills and columns, while the loaders throw back the ore from the face. The drills, of which there are two on this shift, are then set up four feet from the face, and about 20 inches from the rib or side, and each driller puts in five 12-foot center cut holes, B-1, 2, 3, 4, 5, and C-1, 2, 3, 4, 5, respectively (see sketch above) completing the round in about six hours. The holes are blown out with compressed air, when the shift is completed. After having cleared away the face for the drillers, the six loaders clear off the track, run in a trip of three cars and load up the ore thrown up the slope by the previous blast, which sometimes is 100 feet from the face. When the ore is reduced to a heap behind the drillers, one car only is used, and the loaders relieve each other, car about, three at a time. The loaders generally finish at the same time as the drillers and forty to fifty tons is an average shift's work.

The blasters then load the holes drilled with seven pounds of 50 per cent dynamite in each, tamping them securely with paper cartridges of clay prepared for the purpose. After the wires and blasting machinery are tested for strength and circuit the round is fired. If the work has been done correctly, the center cut will be taken out as shown in the sketch, and the ore thrown well up the slope. Owing to the heavy burden on these holes they will be only about half shot out. A little high pressure air is turned on at the face immediately after the blast, and the exhaust fans speeded up. In the course of a short while the air at the face

is quite clear, and while still a little warm, work can be resumed.

The next shift then begins, loaders clearing face as before. The regular drillers now set their bars four feet back from the face and as close to the rib as possible, and drill holes A-1, 2, 3, 4, 5, and D-1, 2, 3, 4, 5, 12 feet deep. In addition to these, two spare drills are set up in the cut and drill holes E-1, 2, 3, and F-1, 2, 3, and G-1, 2, 3, H-1, 2, 3, respectively six feet deep. As the extra drills do not come on the same shift each time, there are two spare drillers on each shift who, when not at this work, repair and advance ventilating pipes, swinging Sampsons, etc., and other odd jobs. .

The order of blasting is now more elaborate than on the previous shift, and on the care taken in this work greatly depends the advance to be gained.

They first load and fire holes F-1, 2, 3, and G-1, 2, 3, three pounds to a hole. Next they fire the old bottoms of holes B-1, 2, 3, 4, 5, and C-1, 2, 3, 4, 5, with three to five pounds each, according to necessity. The third round is E-1, 2, 3, and H-1, 2, 3, five pounds to a hole, and finally A-1, 2, 3, 4, 5 and D-1, 2, 3, 4, 5, are fired, five pounds to a hole. This makes a total of about 200 pounds of 50 per cent dynamite to an advance of 8½ to nine feet, according to the success of the work done.

The method of using short bars and setting up the drills on top of the ore heap was at first tried and practiced for some considerable time, but it was found that while saving a good deal of time in handling the ore, in the long run it did not pay.

The storage, thawing and distribution of the explosives for both the mines and the submarine slope are carried on at a central station which comprises a small magazine, thawing house, with detached boiler room, and a shed for testing detonators, located at convenient distances apart.

The thawing is carried on in a small stone building brick lined and wood faced inside, with an air space between the brick and stone, and the building is provided with a large entry for the reception and disposal of the explosive. It is heated by the ordinary hot water system, but the radiators are closed in wooden boxes to prevent accidental contact with the explosives.

The various blasting crews, wiremen, thawers, magazine storekeeper, and detonator tester, are all under the supervision of an explosive inspector, who constantly inspects all operations connected with the use and disposal of all explosives, and who immediately reports to the underground manager any unusual occurrence, and if possible, the cause of the same.

THE PLANT

Sullivan "UD" rock drills are used in the slope. Compressed air at 80 pounds receiver pressure is supplied to the drills and pumps in both the slope and in the working mines by two cross compound steam two stage air compressors and one straight line compound steam and two stage compressor, having a total capacity of 7,200 cubic feet of free air per minute. This plant also drives small hoists underground, and the fan engines.

The ventilating plant consists of one four-foot and two three-foot Sturtevant fans. The four-foot fan is direct connected to a vertical air driven fan engine, and is located near the upper part of the slopes, just at the bottom of the present workings of the No. 2 Mine, of which the slopes are a continuation. This fan is placed in the air course, and is operated exhausting. The two three-foot fans are placed as described below.

The intention was to sink the slope by double entry. In practice, however, it was found that the tendency was to place chief importance upon the slope farther advanced, with the result that it finally exceeded the secondary or ventilating

slope by a distance of 2,900 feet. To provide for ventilating this long single slope, recourse was had to spiral riveted galvanized iron pipe, connected with two blowers, with a suitable by-pass connection, so that they could be used either as blowers or exhausters. One of these was placed at the upper end of the pipe and the other, reinforcing it, about 1,000 feet further down. The first pipe used was 15 inches inside diameter, and was found to be too small to give entirely satisfactory results. Below the lower fan 18-inch pipe was installed, which still continues to give a plentiful supply of air to the face of the slope. As the slope advances, new lengths of pipe are added. On account of the blasting, the pipe cannot be laid nearer than 150 feet of the face, but no inconvenience whatever is felt.

DAMS

To protect No. 2 mine from possible inundation, sites for mine dams were constructed at a point situated vertically below high-water mark. When approaching this point the face was narrowed to six feet and then gradually widened again forming a "V." No reduction was made in the height. The sides, top, and bottom were lined with concrete. A small pipe was placed in the roof as an outlet for air when the pressure should come on the lower side of the dam, and capacious air and water pipes were built into the floor. Timbers to fill the opening were made of 10 x 10 pine, tapering to 6 x 6 and piled at the mouth of the slope in the same position they would occupy in the dam and carefully protected from the weather.

PIPING

The air line is eight inches in diameter as far as the workings in No. 2 mine and to the large Jeanesville pump, and five inches for the rest of the submarine slope. The water discharging line is six inches, being double from the large pump to the surface.

TESTING AIR PIPES

The air pipes are periodically tested as follows: All pipe ends are carefully closed as near to the drills as possible, and a pressure gauge is connected to the section to be tested. The section is then filled from the mains, and the supply valve closed. The air in the line is then released until the gauge reads 50 pounds, The time is taken and the pressure allowed to drop by leakage until it reaches 40 pounds, when the time is again taken. The loss in cubic feet of free air will be approximately half the volume of the pipe tested. This divided by the time will give the loss per minute. As the amount of pipe in each section is not often changed this information is readily available. The conditions, with the exception of the time, will be practically constant. The pipe fitter is thus constantly familiar with the condition of his pipes. Corrections for temperature would be necessary for accurate results, but in practice are not needed.

CARS

The cars used are of steel, of 30 cubic feet capacity, holding from 1.7 to 1.8 tons of ore.

TRACKS

The tracks are of 28-pound rails, except near the face, where an 18-pound rail is temporarily used. The gauge is two feet.

TELEPHONE SYSTEM

Telephones are installed in the slopes, connecting through a central office with all parts of the works, the office, and the houses of the manager and underground manager.

Efficient and modern electric pumps, fans, hoists, and other devices have been installed and the equipment of these mines is considered to be unsurpassed.

The writer acknowledges with thanks many courtesies and much aid in preparing this article to Mr. A. R. Chambers, manager of the Nova Scotia Steel and Coal Co., and to Mr. L. H. Johnston, manager of publicity for the company.

A MODERN OFFICE BUILDING

To the uninitiated, the construction and equipment of a modern office building are an unfailing source of surprise. The architect of such a building must be a little of everything, from a mining engineer to a skilled accountant, a lawyer, and above all a diplomatist and an organizer. The variety of materials, trades, and departments of engineering, mechanics, and art represented to provide the conveniences and services necessary for carrying on business, and the skill with which these are embodied inside of four walls, are hardly short of marvelous.

One of the best recent examples of these elements is the Peoples Gas Building, now being completed in Chicago by the Peoples Gas Light and Coke Co. at the corner of Michigan Ave. and Adams Street. This building has a frontage of 196 feet on Michigan Ave. and 171 feet on Adams Street. It is 20 stories in height above the sidewalk and has two basements. The concrete and steel piers which support the building, run to a depth of 74 feet below the street level, while the roof is 270 feet above the sidewalk.

This structure forms a prominent and pleasing addition to the imposing façade facing Chicago's lake front. It is probably the largest and in many respects is the most completely appointed office building in Chicago. When finished it will accommodate in the neighborhood of 3,500 people. It contains 416,165 square feet of rentable floor space and is intended primarily to accommodate the Peoples Gas Light and Coke Co., whose old building on this corner was torn down to make way for the new structure.

The company's counting room covers practically all of the first floor and its various departments occupy four entire stories and parts of two others, all connected by an elaborate system of pneumatic tubes, telephones, etc., to permit rapid communication and to save time. The remainder of the 20 floors are available for outside tenants.

The building is of the modern steel cage construction and was erected in halves, the north section being partially completed before the south half was begun, in order to provide quarters for the Gas Company before their old building was torn down. Remarkable speed was attained in the steel construction of both sections. The building contains about 10,000 tons of steel girders and frames and is very thoroughly fire proofed throughout. More than 50 separate contractors and supply concerns co-

The Peoples Gas Building, Chicago

One of the Rockport Granite Quarries

operated in the construction and equipment of this building. A list of these concerns and of their contracts is impossible in the limits of this article.

It may be interesting to note that the plumbing system includes about 40 miles of piping, and 18 miles of piping are required to regulate the 1,200 thermostats which enable each tenant to adjust the temperature of his office to suit himself. The occupants are served by 17 elevators.

No expense has been spared to make

Sullivan Plug Drills

this structure one of the most convenient and artistic in the country. For this purpose the resources of the entire world have been drawn upon for ideas and materials.

The distinguishing feature of the exterior is a colonnade of solid polished granite columns, 18 in number, which rise from the sidewalk to the third floor on both fronts of the building.

These columns are 26 feet in height or 30 feet, including the capitals and bases, and are four feet in diameter. Each column weighs about 32 tons and is said to represent a cost of $3,500. They were supplied by the Webb Granite and Construction Company and were quarried and turned by the Rockport Granite Company of Rockport, Mass., from their "Sea Green" quarry.

The blocks from which they were turned were removed by means of Sullivan rock drills and plug drills from a ledge 200 feet below the surface of the ground. They were handled first by sea and then by freight cars, built especially

Alabama Marble Co.'s quarry

for the purpose, and are the largest monolithic columns in the city of Chicago.

The Rockport Granite Company has an equipment of more than 50 Sullivan Plug Drills and a number of Sullivan Rock Drills at its various openings. The cut shows a number of these tools at work in one of the pits, removing blocks from which columns will be turned later. Air for the quarries and cutting sheds is supplied by a Sullivan corliss cross compound condensing two-stage air compressor of 1,600 cubic feet capacity. The Peoples Gas building is finished or sheathed up to and including the third floor with pink granite from Milford, Mass., and above that terra cotta tile is employed, made to represent granite. An enormous quantity of marble is employed in this building, for the corridor floors, wainscots and fixtures. Alabama white marble, amounting to 115,000 square feet has been used for the wainscots on all floors except the first. This marble came from the quarries of the Alabama Marble Company, Sylacauga, Ala. A general view of this quarry is shown on this page. The stone is first quarried with Sullivan marble channelers, of which seven are in use. Below is shown a pile of blocks as they come from the quarry and on the next page is shown a view of the company's mill where gang saws cut the blocks into slabs which are later polished and cut to size for the wainscot panels.

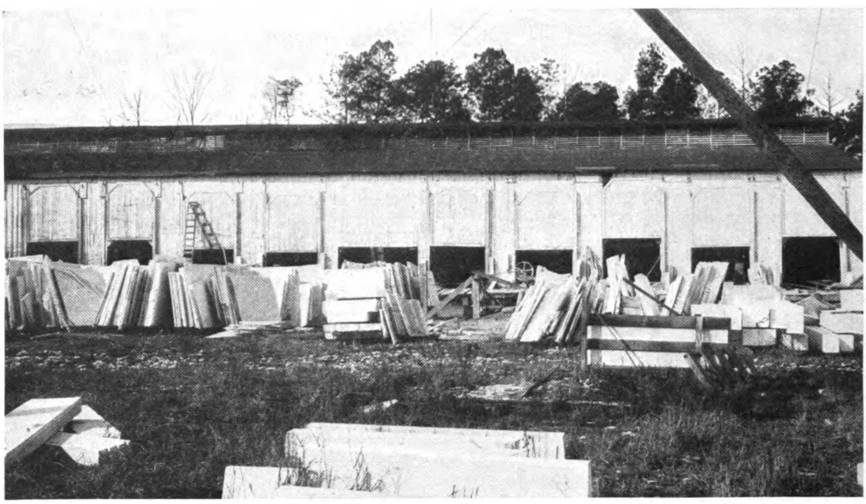
On the main floor of the building Grecian marbles are employed altogether, with the

Quarry blocks of Alabama marble

exception of the handsome fluted columns of Alabama marble at the main entrance to the Gas Company's Offices. The floors of the corridors and toilet rooms throughout the building are Greek Pentelikon stone.

This building is one of four large office structures which have been erected on the lake front in the last six years. Its tenants include a wide variety of professional men, supply and equipment concerns, as well as business and financial houses. The Sullivan Machinery Company, for five years in the Railway Exchange Bldg., one block south, moved its general offices to the fourth floor of the Peoples Gas Bldg. in May, 1910, and now occupies commodious quarters, aggregating 4,000 square feet of floor space, facing the Art Institute and Grant Park.

The architects of the building are Messrs. D. H. Burnham & Co. We are indebted to the officials of the Gas Company and to members of the architects' staff for much of the above information.



The Marble Mill, Sylacauga, Ala.

CUTTING LOW COAL BY MACHINE IN PENNSYLVANIA

By Geo. M Crawford*

The Central Pennsylvania coal fields contain numerous mines in which the seam is only from two to three feet in thickness. To mine this coal profitably is a serious problem, on account, first, of the large amount of dead work, such as lifting bottom or removing top in headings and air courses to give proper height for haulage and ventilation; second, because of the severe competition from West Virginia. In the latter field the coal is higher and labor cheaper, so that it devolves upon the thin seam operator to cut down his cost of production to the lowest possible point, in order to make a reasonable margin of profit.

These conditions have created a demand for a machine which will mine more rapidly and cheaply than is possible by hand labor, and enable the highest possible percentage of lump coal to be produced.

SHAWMUT MINING COMPANY

One of the concerns in the district referred to, which has felt the pressure of these conditions and has made a careful study of the situation, is the Shawmut Mining Company, with offices at St. Mary's. This concern operates nine mines in the southern part of Elk County, on the lines of the Pittsburg, Shawmut and Northern Railroad. Most of these work the lower Kittanning Seam, which ranges from two to four feet in thickness. At the No. 5 mine at Elbon, about 20 miles from St. Mary's, the average height of coal is two feet eight inches, and the problem of methods which would make operation profitable has been a hard one for the company to solve.

ELBON NO. 5 MINE, SYSTEM OF MINING

The Elbon Mine is worked on the double entry, room and pillar system; one entry is used as a haulage and manway, the other for an air course. These main entries are driven ten feet wide, with 50 foot centers, leaving a pillar 40 feet thick between them. The cross entries are run every 350 feet, and from these the rooms are turned. A 50-foot supporting pillar is left on each side of the cross entries. The rooms are driven 250 feet in depth, on 60-foot centers, that is, are 40 feet wide, leaving pillars 20 feet thick. All entries, room-necks, and break-throughs are ten feet wide, and entries and air courses are five feet high, top being removed to secure this additional head room. The roof is of slate, generally of good strength, which permits wide rooms to be driven. The coal is underlaid by fire clay. A track is laid up each side of the room, six to eight inches of the bottom being lifted by the miners to give height for cars. The coal is reasonably free from sulphur, except at the bottom of the seam, where it appears in streaks or bands, rendering undercutting slow and difficult at times.

MINING METHODS

Until about a year ago the coal in this mine was undercut by electric chain breast machines and by hand pick. At that time a Sullivan continuous cutting self-propelling chain machine was installed. The results obtained with this machine were so satisfactory as to decreased cost of mining and as to the percentage of lump coal produced, that the company has placed Sullivan machines of the same type in its other mines. These machines are known as the Class "CE6" and are especially arranged for mining in low coal. Practically all operations are performed by the machine under its own power, doing away with the difficulties and loss of time involved in moving a machine of this size and weight in a space less than three feet high.

*Pittsburg, Pa.

Sullivan Low Vein Continuous Coal Cutter making a rib cut, Elbon Mine No. 5

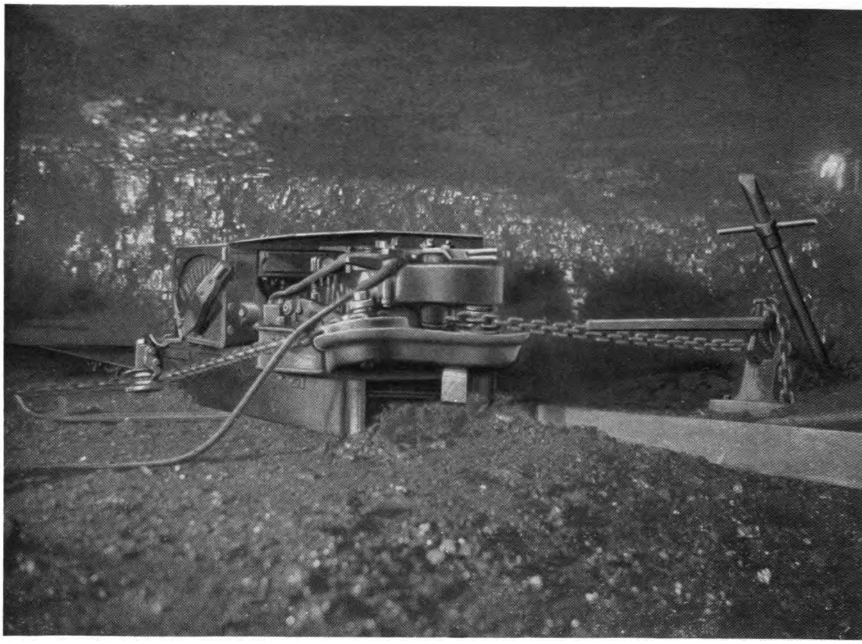
From another point of view, it is unnecessary to sacrifice strength in machines of this type in order to make them easier to lift or move about. The photographs on pages 468 and 470, taken in the Elbon Mine, show how the machine is used. It moves from place to place on a self-propelling electric truck, loading and unloading itself, without hand labor.

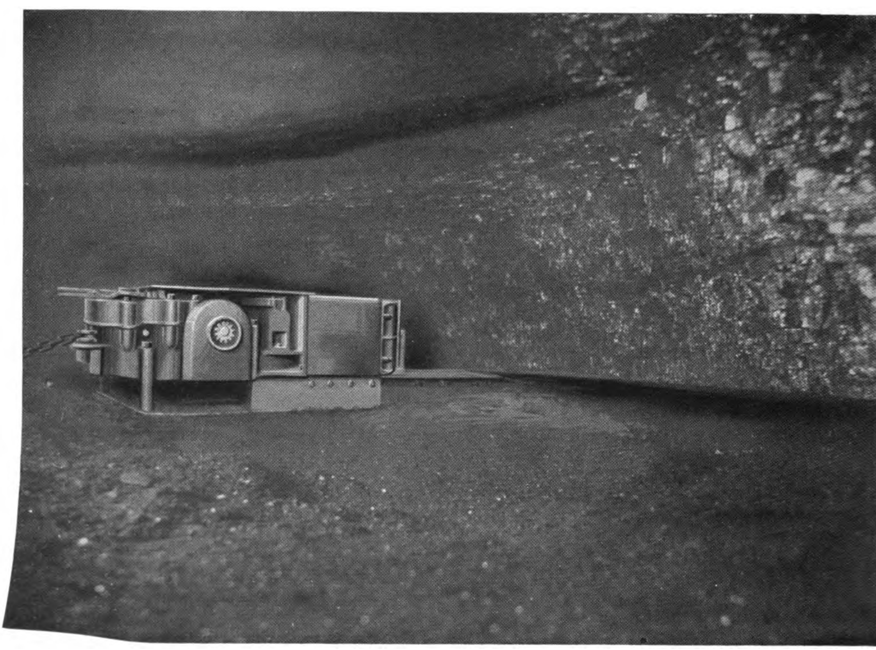
MINING MACHINES

The Sullivan "CE6" machine stands 31½ inches high above the rail, on its self-propelling truck. When mining, it travels on a flat steel shoe or plate and is but 21 inches high. It weighs 3,100 pounds, and the power truck 900 pounds, and develops 30 H. P. while cutting. This is about double the power of the ordinary chain breast machine. Instead of the triangular cutter bar with open frame, a straight bar 21 inches wide from pick point to pick point is used, and this is covered with a shield. When coal settles after being cut, these features enable the Sullivan machine to cut itself clear. The "CE6" works on the same principle as the high vein Sullivan room and pillar machine. After sumping at the rib it becomes virtually a long wall machine, traveling across the face of the coal under its own power, on a feed chain stretched between two jacks, one at each side of the room. The cutter bar remains under the coal until the other rib is reached and in this position the machine occupies only about five feet in front of the face, so that posts may be set permanently at that distance. This is a valuable element of safety in mines where the roof is weak. The ordinary breast machine must be backed out and barred over by hand after each cut or "board," and as the machine is from 11 to 14 feet long, this means considerable labor and not a little danger in tearing down and re-setting props. Another advantage of mining with "Continuous Cutters" is that the cars may be brought closer to the face, and the work of the loaders made more rapid. The kerf or undercut is five inches high, enabling the coal to roll well forward when shot, and securing more lump and less slack on account of the smaller amount of powder needed to bring down the coal. The undercut is five feet and three inches deep. The photograph on page 472, taken in the No. 5 mine, after cutting and shooting, indicates the grade of coal produced by this means. The slack from the cutting is not dust, but near the size of nut coal.

The cutter chain and feeding mechanism of the Sullivan machine are operated through gearing, so controlled that the motor, which is of the horizontal, shunt-wound type, runs continuously, and the cutter chain or feed gears are thrown in or out of motion independently. The operator can manipulate the machine on the feed chain so as to throw the cutter bar forward or behind the body of the machine, to cut around obstacles, such as black jack or sulphur balls in the coal. Feed gears are available which will carry the machine along the face at from 16 to 39 inches per minute. In this mine, an 18 inch feed is employed, owing to the hard cutting mentioned above. The operator can vary the speed as required from a fraction of an inch per minute up to the full 18 inches. The feed gearing is protected by a friction clutch, set to slip when a certain draw-bar pull is exceeded. This relieves the machine of undue strain, when sulphur, bone, or other hard materials are met with, and reduces to a low factor the breakage threatened by such conditions.

This machine cuts a level floor and leaves no bottom coal to be raised before the next advance can be made. Gradual rolls are followed readily. In the Elbon No. 5 Mine coal is produced by the Sullivan machine for about one-half of the cost of mining with the breast type. To shoot the coal, as shown on page 472, a 1¼ x 6 inch cartridge is placed in the





Sullivan machine in Elbon Mine, above, at end of rib cut; below, crossing the face, right to left

center, for the tight shot, and a 1¼ x 8 inch cartridge is used on each rib.

HAULAGE

The mine track gauge is 30 inches; iron rails are laid in the entries and wood rails in the rooms. The mine cars hold 1,000 pounds each. They are handled by the loaders in the rooms, and are gathered at the room-necks by eight-ton electric locomotives, of which five are in use, and hauled in trips of 35 or 40 to the tipple. As the empties are hauled along the cross entries they are distributed to the loaders, and the loaded cars gathered and pushed ahead of the locomotive. When the last empty has been distributed, the locomotive has a clear track to haul the loads to the outside. The distance from the face to the tipple is now about two miles. A system of signal lights is installed along the entries for directing the motor-men.

VENTILATION

The mine is aired by an 18 foot ventilating fan, operating as a blower.

PRODUCTION AND LABOR

The No. 5 mine is now producing about 500 tons per day; about 125 miners are employed and live in company houses near the mine.

MANAGEMENT

Mr. Frank Sullivan Smith, of New York City, is President of the Shawmut Mining Company. Mr. Geo. S. Ramsay, of St. Marys, Pa., is general manager, and Mr. W. R. Craig, also of St. Mary's, is chief engineer; Mr. James Jones, superintendent of the Shawmut and Elbon mines, and Mr. Jno. Murray, chief electrician, are both of Shawmut, Pa. Mr. Wm. Faulk, of Elbon, is the mine foreman.

To Mr. Ramsay belongs much of the credit for the successful development and profitable operation of the company's properties. Beginning in 1898 as superintendent of three mines at Shawmut and Elbon, he became general superintendent in 1900, and in 1910 general manager, with nine mines under his direction.

In addition to the mines of the Shawmut Mining Company, Mr. Ramsay also has under his management the Allegheny River Mining Co., which owns one of the above shipping mines, and now has under development five new mines from which it expects to produce 11,000 tons daily. These last named mines are located in Armstrong County, on the Pittsburg and Shawmut Railroad, which connects with the Pittsburg, Shawmut and Northern. Credit is due Mr. Ramsay for his ability and energy, in developing new mines and in increasing the output of the older openings.

The writer is indebted to Messrs. Craig and Jones for their courteous assistance in furnishing data for preparation of this article.

A loaded trip

DRIFTING WITH A STOPING DRILL

By H. E. Moon*

It is interesting to note the ingenuity displayed by some miners, especially those who are leasing, in keeping down operating and equipment costs.

An example of this recently came to the writer's attention in the Cripple Creek District of Colorado. Two miners had a lease on one of the lower levels of the Granite Mine. Their work was entirely stoping and raising and their drill equipment consisted of air feed stoping drills.

They drove the raises "A" and "B" Fig. 1. Owing to heat and bad air and also to assist in opening the stope, they decided to drive the drift "C" from "A" to "B," thus giving a chance for ventilation. They could not afford to purchase a drifting drill, but with the aid of a simple foot-plate they found that they could use a stoping drill to put in holes at all angles from the vertical to the horizontal. In one case they put in a hole five feet deep which dipped about four inches below the horizontal in that distance.

This foot-plate (Fig. 2) was made of a sheet of 3/8-inch steel, with ears turned down at the corners to act as spikes and hold the plate onto a plank. To this plate was riveted a piece of angle iron bent to a "U" shape.

The drill used for this work was the new Sullivan Class DA-21 stoper. The ground was a hard granite. The cutting speed was from 14 inches a minute, in vertical holes, to eight inches a minute in horizontal holes. A blow pipe was connected with the air supply and used to clean the cuttings from flat holes.

(Sullivan Stope Drills are in use in the anthracite coal fields of Pennsylvania for work like that described above, for driving short tunnel headings. In this instance, hand feed hammer drills are used to drill down holes in the face. The rock next the tunnel floor is then shot out, and the stoper used to drill upper holes.—Ed.)

*Denver, Colorado.

A room after shooting; note the large amount of lump coal

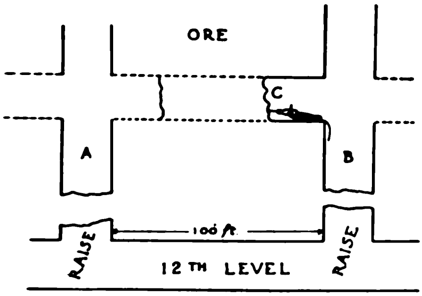


Fig. 1. Plan of raises and drift

Sullivan Stope Drill in a copper mine

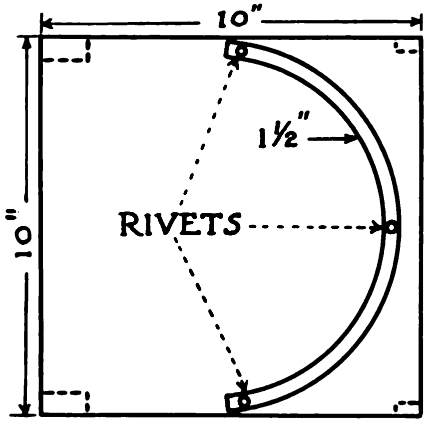


Fig. 2. Plan

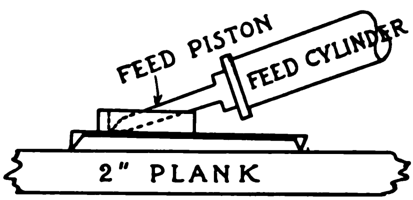


Fig. 2. Foot plate for Stope Drill. Elevation

IMPROVEMENTS TO THE ST. MARY'S FALLS CANALS

R. J. Raley*

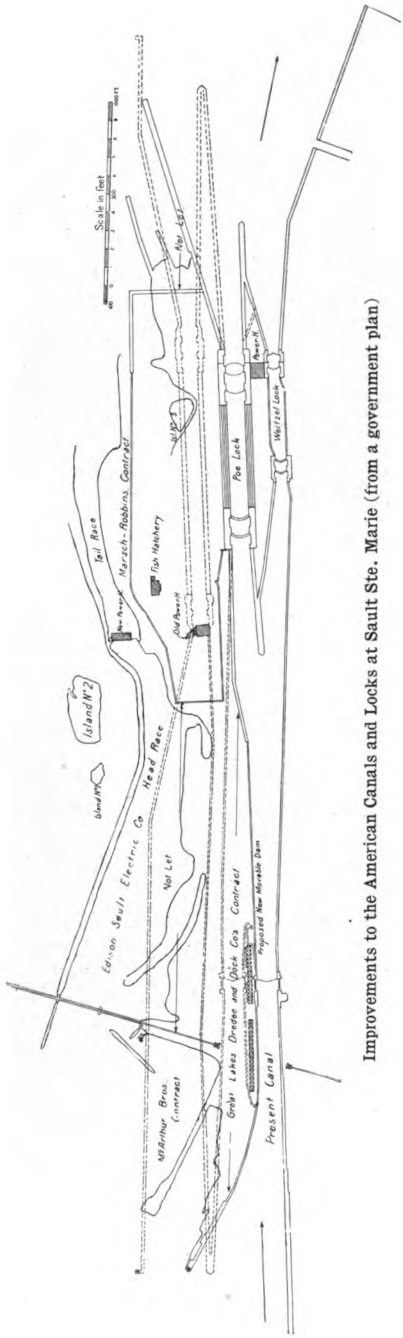
For several years the United States Government has been improving the facilities for handling vessel traffic at the Sault Ste. Marie. In 1897 the tonnage carried between Lake Superior and the lower lakes amounted to 19,000,000, while in 1909 it had risen to nearly 58,000,000 tons. Work carried on in the past three years has provided a double channel below the locks, 21 feet deep and each half 300 feet wide. The new West Neebish Channel, a channeled rock cut 8,800 feet long, was described in the June, 1908, Mine and Quarry.

*Duluth, Minn.

The locks themselves and their approaches are now receiving attention which has been badly needed for several years, on account of the increase in the size and draft of the vessels, as well as their number. These improvements consist, first, in widening the approach to the Poe and Weitzel locks to 300 feet throughout, and in constructing an entirely new canal and lock, north of the present channel.

CANAL WIDENING

The sketch on page 474 shows the work covered in widening the old canal. Previous to this improvement, delay was caused by the fact that at the interna-



Improvements to the American Canals and Locks at Sault Ste. Marie (from a government plan)

tional bridge, the channel was only 125 feet wide. The strip excavated is about 125 by 4,000 feet; work was begun in March, 1908, and completed before the opening of navigation in 1910, by the contractors, the Great Lakes Dredge and Dock Co., of Chicago.

The quantities of material to be excavated and the contract prices were as follows:

Dirt excavation and dredging, 135,000 cubic yards, at	$0.55
Rock excavation, 260,000 cubic yards, at	1.30
Rock channeling, 85,000 square feet, at	.30
Revetment wall timber, 150,000 cubic feet, at	.10
Filling above with stone, 20,000 cubic yards, at	.30
Concrete, 7,000 cubic yards, at	4.00
Special concrete, 9,500 cubic yards, at	5.00

The total depth of the excavation averaged 30 feet, of which from 7 to 9 was earth and the remainder rock, consisting principally of Potsdam sandstone. About 1,400 lineal feet of timber crib walls were built and 3,700 lineal feet of concrete walls.

Prior to letting the contract, the United States erected a coffer dam at the upper end of the work, which permitted the excavation to be carried on in the dry. To avoid interruption of traffic, a strip or rib of rock about 40 feet thick was left between the old canal and the new channel. This wall or rib was blasted out during the winter of 1909–1910, after the remainder of the excavation was completed, during the period that the canal was closed to navigation.

CHANNELING

The photograph on page 475. looking up stream from the locks on March 27th, shows this work very plainly. The old channel is at the left of the outer approach and the extension at the right. Both

Looking west from the Locks; widening the approach

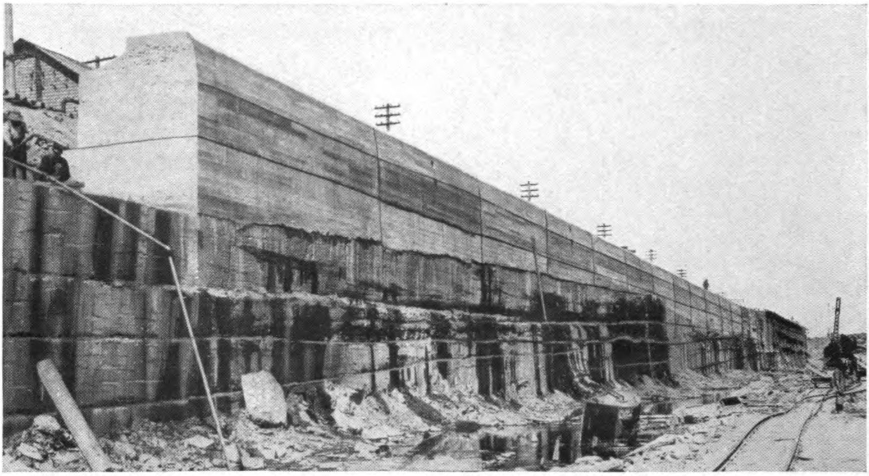
the rib and the outside wall were cut by stone channeling machines before the material between them was excavated. This was done in order to avoid shattering the walls and weakening them, and also to secure a smooth and even finish to reduce friction of the flowing water and to prevent accident to vessels touching the walls. This would have required trimming or filling in after the excavation was completed, if the blasting had been carried up to the walls themselves.

The contractor's plant for this work included two Sullivan Class "Y8" channeling machines, each carrying its own boiler; and 12 standard Sullivan Class "UF11" 3¼-inch rock drills. These were operated by air from a 1,200 foot Sullivan "WJ" two stage, self-oiling air compressor, driven by belt from a 150 K. W. synchronous motor, taking alternating current from the Soo Edison Co. at 4,000 volts.

The contractor's equipment also included two steam shovels, four dinky locomotives and a large number of dump cars. The conditions for drilling and channeling were exceedingly difficult. Much of the work had to be done during the winter, when snow, ice, and zero weather were the rule. The rock encountered consisted of ledges of varying hardness, interspersed with mud holes and pockets. The overburden was a conglomeration of broken rock, hard pan, boulders, sand, gravel, and clay. The severity of the climate made it difficult to secure the proper class of labor and the area available for dumping the spoil was small and difficult of access. When these points are considered, the record made by the contractors in handling the work and in finishing it in season to open the canal for early navigation last spring, is a commendable one.

NEW CANAL AND LOCK

The river and harbor act of March 2, 1907, empowered the secretary of war to construct a new canal and a third lock, at a cost of not over $5,000,000. This canal will be 300 feet wide and about 7,000 feet long, between the ends of the protection piers. The new lock will be



The channeled side wall, approach channel

A Sullivan "Y8" Channeler, housed for winter work

1,350 by 80 feet, and 25.5 feet deep over the miter sills. It will have a vessel capacity equal to the Poe and Weitzel locks combined, which are 800 x 100 feet and 550 x 80 feet in size, respectively.

The new lock at the Soo is parallel to the present locks and 190 feet north of the north face of the Poe lock. The improvement is shown by the dotted lines in the sketch on page 474, made up from the government engineer's drawings.

It is estimated that the new canal and lock will be in service in 1914. The excavation for the improvement is divided into four main sections. Approximately 2,400 feet, west of the international bridge, has been awarded to McArthur Bros. of Chicago, and the excavation of the lock and its immediate approaches is now being executed by the Marsch-Robbins Co. also of Chicago.

LOCK EXCAVATION

The contract for the lock excavation was awarded in August, 1909. The area within the limits of the excavation is about 2,200 feet long, 132 feet wide, and about 30 feet deep. The amount of material to be removed consists of about 143,800 cubic yards of earth excavation and 242,500 yards of rock. The overburden contained sand, gravel, timbers, broken rock, blocks of mass concrete, clay, hardpan, and boulders. The bed rock is Potsdam sandstone, in layers from a few inches to six feet thick, with scattering mud seams and pockets. The contract prices were: earth, 47½ cents per cubic yard; rock, 93½ cents; channeling, 29½ cents per square foot.

SURFACE EXCAVATION

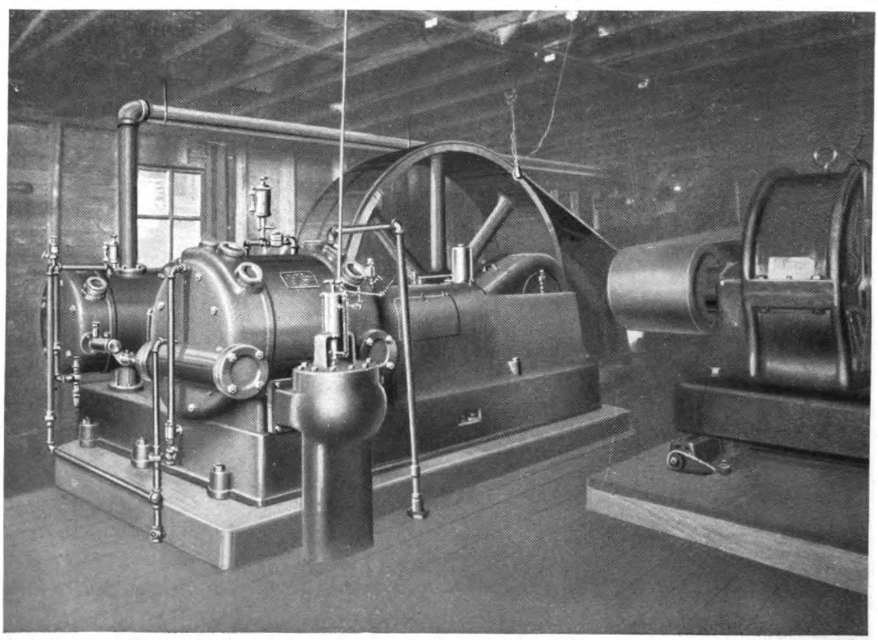
The government had constructed a coffer dam, enclosing the area to be excavated, before work began. The Marsch-Robbins Co. were required to keep this in repair and free from water. An equipment of six electric driven centrifugal pumps, ranging from four to ten inches in size, handles the water (under 60 foot head from Lake Superior), without difficulty. A 45-ton and a 95-ton steam shovel were employed to strip the overburden, and are still in use to remove the blasted rock. The spoil is loaded by the shovels in ten car trains of 4-yard western side dump cars, and hauled to the dump by six 18-ton locomotives. The dump is due east of the pit, in the river, and the spoil is deposited from a trestle.

CHANNELING

The specifications require that the side surface walls must be channeled before blasting is done within 15 feet of the walls; and that only small charges are to be used near the walls, so as not to disturb the rock face. There are about 139,000 square feet of channeling to be done, or 8,000 lineal feet. The depth of cut ranges from 10 to 25 feet. For this work, four Sullivan "Y8" Channelers are employed, each carrying its own boiler. The progress made has averaged between 70 and 80 square feet per eight-hour shift, with a high run of 336 feet in 13½ hours on January 14, or a run 24 feet long by 14 deep. On Jan. 18 one machine cut 264 feet, and on the 14th another cut 261 feet in eight hours. The latter record was made in six hours' cutting time.

The clay and sand pockets and seamy rock have frequently reduced headway in channeling, and trouble has also been encountered from water and from the heavy side pressure after the cut is down six or eight feet. Compressed air is used to pump mud and cuttings out of the channel. Page 476 shows a channeler housed for the winter. This picture was taken in December with the thermometer 12 degrees below zero. The picture on page 478 indicates the general character of the excavation and the channelers appear in the background. Note the dip of the rock, as shown by the bedding planes. The boat is in the Poe lock, less than 200 feet away.

The new lock; Sullivan Channelers at work



Sullivan motor-driven air compressor

ROCK DRILLING

Drilling is done by 21, 3¼-inch piston rock drills, which put down nine-foot holes, bottomed with a gauge of two inches. The drills average 4.75 feet of hole per hour. The holes are spaced four feet apart on a line 35 feet long across the lock chamber. They are loaded with 14 sticks of 40 per cent dynamite. Two exploders are used in each hole and from one to 150 holes are fired at a time, by an electric battery. Within the lock limits, and wherever concrete is being placed, blast holes are stopped at least one foot above the grade, to avoid shattering the bed rock.

Great care has to be exercised in blasting, because of the proximity of the city streets, the tourists in the park adjoining the canals, and the boats passing through the locks. Fragments of rock too large to be handled by the shovel dippers, are left at one side and broken up by pop holes, drilled with Sullivan "DB19" hand feed hammer drills. There is a great deal of this work, as the rock breaks into coarse fragments. The contractors have found the hammer drills almost indispensable, since the "mud-cap" method would have resulted in heavy window breakage in the city.

To break a rock fragment 5x5x4 feet requires one hole 28 or 30 inches deep, and about [illegible] pound of 40 per cent dynamite, with one exploder. For "mud-capping", at least five pounds of dynamite would be needed. The saving in explosive alone is therefore an important item. Seventy or 80 of these holes have frequently been fired at once.

The drills are operated by compressed air, furnished by a steam driven, two-stage, straight line compressor, and by a Sullivan Class "WJ" 1,200 foot two-stage compressor of the duplex, self-oiling pattern, driven by belt from a motor. (See page 478.)

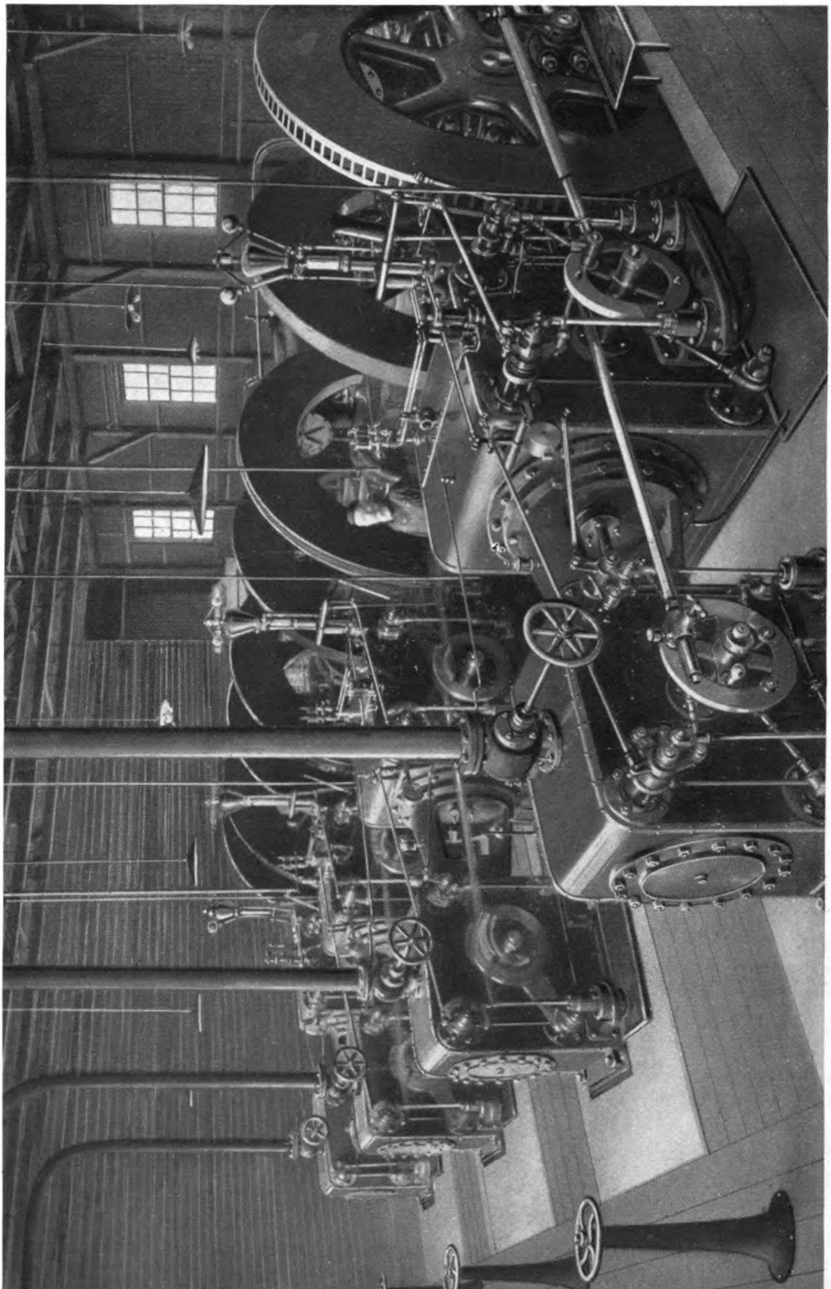
The air is reheated before it is used, to prevent freezing at the drill exhausts in the extreme weather. Three-inch pipe coils are placed in the main air lines, close to the manifold connections for the drill hose, and open fires are built around the coils, which are connected into the main with unions so that they can be moved from place to place.

Sullivan Hammer Drill block-holing

Three eight hour shifts are worked, beginning at 7:00 A. M. Monday and stopping at 7:00 A. M. Sunday. The work is lighted by incandescent bulbs. Labor is obtained chiefly from the city of Sault Ste. Marie. The excavation is now about 75 per cent completed.

The contract includes the excavation of a large well, 70 feet deep by 31 feet in diameter, from which several tunnels, six by nine feet in size, run to the lock. The tunnels are from 35 to 85 feet long. Pumps, located in the well, will pump the water out of the lock at the close of navigation.

The writer is indebted to Mr. L. H. Robbins of the Marsch-Robbins Co. and to Mr. L. C. Sabin, assistant U. S. Engineer, and general superintendent of the St. Mary's Falls Canal, for information used in this article. Col. L. McD. Townsend is in general charge of the work.



Sullivan Corliss Tandem Air Compressors at Firthcliffe, N. Y.

AIR COMPRESSOR ECONOMY ON THE NEW YORK AQUEDUCT

The Catskill Aqueduct, for supplying New York City with water, is notable for its length, 150 miles, its ultimate cost, about 160 millions of dollars, and the engineering difficulties encountered in its construction.

The hilly country through which the aqueduct runs has made necessary the boring of numerous tunnels through solid rock. The contractors on these sections have installed construction plants comprising, in many instances, equipment of the highest grade and most economical type. This is particularly true of the air compressor installations, since air power is employed in very large amounts, for running rock drills, concrete mixers, pumps, and other machines.

A compressor plant of unusual interest to engineers is that of the Mason and Hanger Company, at Firthcliffe, New York, near Cornwall-on-Hudson. This firm holds the contract for driving the Moodna siphon or pressure tunnel. Their plant consists of four Sullivan tandem corliss two stage air compressors, each with a piston displacement of 2,450 cubic feet of free air per minute, at 100 revolutions, providing a total capacity of nearly 10,000 cubic feet. The steam cylinders are 20 and 34 by 30 inches and the air cylinders 18 and 30 by 30 inches in size. Both the high and low steam pressure cylinders are equipped with full corliss valve gear, the knock-off cams being actuated by dash pots. The point of cut-off is automatically varied by means of a co-ordinating speed and pressure regulator, which is dependent on both the steam and air pressure for its action.

The air cylinders are fitted with rotary inlet valves, mechanically driven, and with automatic, air cushioned, poppet discharge valves. Unusually large water-jacket and intercooler area secures the highest possible benefits from compressing the air in two stages.

The tandem arrangement of the cylinders in these compressors renders them very desirable for contractors' use. The photograph on page 480 shows the small house room occupied by these four units. Cross compound machines of the same capacity and steam economy would require about twice the foundation and floor space, and at least double the expense and time for installation.

Each of these compressors weighs about 41 tons, and the ease and rapidity with which this heavy machinery was set up and placed in running order in the Mason and Hanger plant was remarkable. As these machines are practically self-contained, they may be moved from one job to another with little difficulty and at low cost, compared with other types. By purchasing several of these units rather than one or two very large compressors, the owners have secured higher operating efficiency than would otherwise be possible. If not enough air is required to keep the whole plant busy, two or three units are kept running at full load and efficiency, the variable load being handled by one of the remaining compressors. A single large unit, under such conditions, would be obliged to run at only part of its rated capacity, with a commensurate drop in efficiency.

This compressor plant takes steam at 140 pounds throttle pressure, from water tube boilers, burning anthracite coal under forced draft. The condensing plant is of the central barometric pattern. No reasonable expense was spared to make this plant as economical as possible in operation, and some excellent records in efficiency have been secured. These four compressors are used by the Mason and Hanger Company for supplying air at 110 pounds receiver pressure to the five shafts and nine working faces, by means of which they are driving the Moodna Siphon.

MINE AND QVARRY

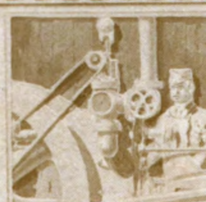
VOL. V. No. 4 MAY, 1911 WHOLE No. 18

THE SULLIVAN AUTO TRACTION ROCK DRILL

THE STRAWBERRY VALLEY TUNNEL

THE AUTO TRACTION DRILL

THE CRANBERRY IRON MINES



PVBLISHED BY THE SVLLIVAN MACHINERY CO. 122 S. MICHIGAN AVE., CHICAGO

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MINE AND QUARRY

Vol. V, No. 4 MAY, 1911

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

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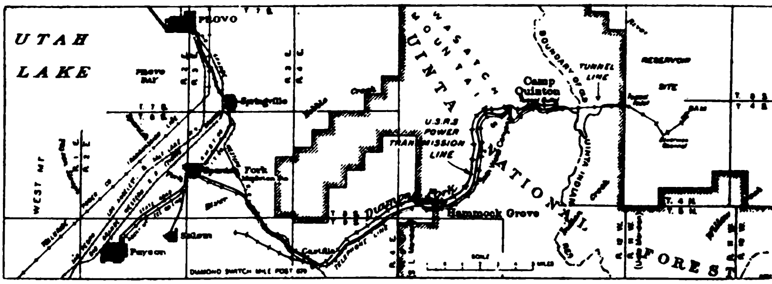
Readers are requested to notify MINE AND QUARRY of any correction or change in address.

This issue of MINE AND QUARRY marks the completion of its fifth year. During this time there has been no alteration in the character or standards of the paper, and none is now contemplated, except such as will increase its interest and usefulness as a "Bulletin of News for Superintendents, Managers, Engineers, and Contractors." The practical side of mining, quarrying, and engineering work, the methods and machines and tools used to solve problems and reduce costs in these fields — these are the things with which MINE AND QUARRY has concerned itself and which it will continue to illustrate and expound. Readers are encouraged to use this magazine as an information bureau, and as a clearing house for discussion of such topics as are of particular interest to them. Lastly, your subscription to MINE AND QUARRY expires when you cease to be interested in it, and the editors depend on you to notify them when you are tired of seeing it. Send in a card once in a while to let them know that your copy has escaped the waste basket. There are a few sets of MINE AND QUARRY for 1910 waiting to be distributed. These will be sent out as long as they last, in a neat binder, which is large enough to hold your 1911 copies too. An index to all the issues thus far published accompanies this number.

The "Auto Traction Drill" and "pump steel" are terms which now imply but little to engineers and contractors. To those who are familiar with their performance on the Livingstone Channel of the Detroit River, they stand for the greatest advance in the science of rock removal, in quarries or open cuts, that has been made since the invention of the machine drill. There has been for some time past no radical improvement in the drill itself. Mechanical details have been bettered, air consumption and repair costs have been decreased, and cutting speed raised, without any important progress in rock excavating efficiency. The chief source of *inefficiency* has remained the loss of time involved in changing steels and in shifting the drill and its mounting from one hole to another. Air feed stoping drills and hand feed hammer drills have reduced these losses to a great extent in certain classes of rock excavation, by their lack of a mounting and their lightness and convenience. European engineers have shown a way to rapid progress in tunneling by mounting their drills on special carriages instead of the orthodox column. The auto traction drill saves time by drilling holes to their final depth without changing steel, or with but few changes, as compared with tripod-mounted machines; by moving from one hole to the next, under its own power, and by employing "pump steel," which prevents the drill cuttings from forming a cushion between the cutting edge of the bit and the solid rock in the hole.

The work of this novel drill and some of its details, are described elsewhere in this issue.



Map of a part of Utah, showing location of the Strawberry Valley Tunnel and area served by this project.

THE STRAWBERRY VALLEY TUNNEL OF THE STRAWBERRY VALLEY IRRIGATION PROJECT OF UTAH

By M. G. Doll *

The Strawberry Valley Tunnel is part of the Strawberry Valley Irrigation Project, undertaken by the United States Reclamation Service. This project when completed will reclaim about sixty thousand acres of mesa and bottom land, lying about sixty miles south of Salt Lake City on the east and south shores of Utah Lake, in Utah and Wasatch Counties. (See general map.)

Most of the land comprising this project has been under cultivation for a long time, but the owners of the bench land were severely handicapped, and the owners of the bottom land, skirting Utah Lake for miles inland on the east and south, had a very inadequate supply of water, from Spanish Fork River. The fact that nearly any sort of a crop could be harvested at a profit under these conditions, led the farmers to fathom out a system of irrigation more voluminous and constant than could be realized from dependence upon rainfall. After a lengthy investigation by government engineers, the project was reported feasible. This eventually brought about a contract between the government and the owners of the land for the construction of the Strawberry Valley Project, the work to be paid for after its completion by the landowners in ten annual payments, without interest.

* University Club, Salt Lake City.

Nature of Project

The project consists of a large storage reservoir, thirty miles of concrete lined canals for distributing the water to the various irrigation ditches, and a tunnel for the purpose of conducting the water from the reservoir through the rim of the great basin, to the main canal.

The capacity of the reservoir will be 110,000 acre feet of water. It covers an area of 6,000 acres in the great basin and stores the flood waters of Indian Creek, Strawberry River and their various tributaries. The watershed furnishing this water is 200 square miles in extent. The dam across the Strawberry River, necessary to form the above reservoir, will be 45 feet in height, 325 feet in length, and 25 feet wide across the top. The construction work on this dam and reservoir will be started this year, as soon as weather permits.

From the great basin the water is taken through the rim by means of a tunnel, which will be described later. From the west portal of this tunnel the water will be lowered about 1,500 feet through the canyon of Sixth Water Creek, thence through Diamond Fork River, and so into the main canal in the valley and from there into the various diversion canals and finally to the irrigation ditches.

The drop of 1,500 feet through the can-

yon of Sixth Water Creek, may be utilized at a later date for power purposes.

The construction work on these canals has been in progress since 1907.

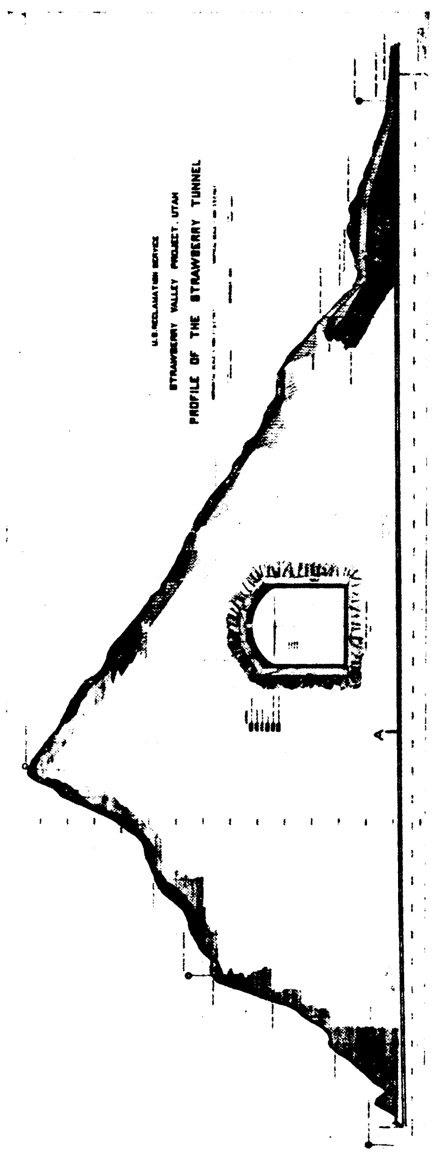
Preliminary Work

On account of the vast amount of cement to be handled, together with the other necessary supplies, it was found necessary to establish and maintain a railroad station for the exclusive use of the government. This was located about one mile west of Thistle on the main line of the D. & R. G. R. R. in Utah and was named Diamond Switch. A freight house, barn, boarding-house, office, and the necessary living houses for the men employed at this plant are maintained at this station. These buildings and their general layout are shown in the cut.

From this station to the construction camp maintained at the west portal of the Strawberry Tunnel, which is called Camp Quinton, it was necessary to build a new road on account of the bad condition and very uneven and steep grades of the old road, which was practically nothing more than a trail. This new government road is about 22 miles long and a uniform grade is maintained throughout, the entire rise from the railroad station to the tunnel portal being 1,500 feet. A load of five tons may easily be hauled over this road by six horses in one day, without any undue strain on the teams. It is necessary to haul the entire annual supplies during the good weather from June 1st to October 1st, as the road, on account of the snow and deep mud, is absolutely unpassable with freight wagons during the late fall, winter and early spring. All freight wagons must be equipped with tires at least 3½ inches in width. This reduces the necessary labor and expense of maintenance of way to a minimum, for the reason that the road is being continually packed down instead of being cut up as would be the case with heavily loaded wagons and narrow tires.

A snow fall of 300 inches was registered at the government station at the west portal of the tunnel between September 1, 1909 and June 1, 1910. The greatest fall was in February, when forty-two inches of snow fell in forty-eight hours. At this time of the year, the construction camp at the west portal is practically snowbound.

Diamond Switch, Utah, where the supplies leave the railroad.



Profile of the Strawberry Valley Tunnel.

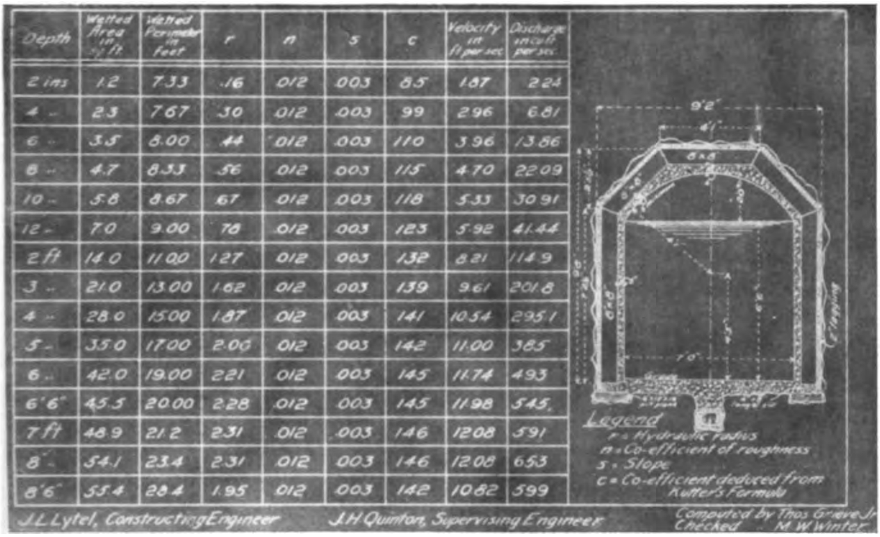
POWER PLANT

The construction work on the tunnel portal, camp buildings, and general outside work, was started in the fall of 1906, but the tunnel construction proper progressed very slowly, on account of various difficulties, among them the lack of power. In order to supply this necessary power, at this point, it was found necessary to install a hydro-electric power plant in the valley. This plant was located near the town of Spanish Fork, Utah, and now furnishes all the power for the construction work and also furnishes the light and power for one or two of the neighboring towns. The cost of this plant is entirely charged out in the footage cost of the tunnel, so that when the tunnel is finished, the plant will be paid for.

The power is generated at 11,000 volts, then stepped up to 22,000 volts, and transmitted over a line about 30 miles in length to the tunnel, where it is again stepped down to 2,200 volts.

STRAWBERRY TUNNEL

The east portal of the Strawberry Tunnel is located at an altitude of about 7,500 feet above sea level and about 1,500 feet below the crest of the rim of the great basin, which it pierces. This portal is about 32 miles by road from Diamond Switch. The total length of the tunnel is 19,000 feet. A uniform fall of two feet per 1,000 is maintained from the east to the west portal. The general dimensions of the tunnel cross section are nine feet six inches in width at the grade line by about ten feet in height. The walls from the grade line to the spring line of the arch or invert are vertical and seven and



Depth	Wetted Area in sq ft	Wetted Perimeter in feet	r	n	s	c	Velocity in ft per sec	Discharge in cu ft per sec
2 ins	1.2	7.33	.16	.012	.003	85	1.87	2.24
4 "	2.3	7.67	.30	.012	.003	99	2.96	6.81
6 "	3.5	8.00	.44	.012	.003	110	3.96	13.86
8 "	4.7	8.33	.56	.012	.003	115	4.70	22.09
10 "	5.8	8.67	.67	.012	.003	118	5.33	30.91
12 "	7.0	9.00	.78	.012	.003	123	5.92	41.44
2 ft	14.0	11.00	1.27	.012	.003	132	8.21	114.9
3 "	21.0	13.00	1.62	.012	.003	139	9.61	201.8
4 "	28.0	15.00	1.87	.012	.003	141	10.54	295.1
5 "	35.0	17.00	2.06	.012	.003	142	11.00	385
6 "	42.0	19.00	2.21	.012	.003	145	11.74	493
6'6"	45.5	20.00	2.28	.012	.003	145	11.98	545.
7 ft	48.9	21.2	2.31	.012	.003	146	12.08	591
8 "	54.1	23.4	2.31	.012	.003	146	12.08	653
8'6"	55.4	28.4	1.95	.012	.003	142	10.82	599

Legend
r = Hydraulic radius
n = Co-efficient of roughness
s = Slope
c = Co-efficient deduced from Kutter's Formula

J.L. Lytel, Constructing Engineer — J.H. Quinton, Supervising Engineer — Computed by Thos Greive Jr — Checked M W Winter

Table of carrying capacity, velocity, and discharge, Strawberry Valley Tunnel.

one-half feet in height. This tunnel is designed so that inside of the concrete lining, it will have a carrying capacity of 500 cubic feet of water per second at a velocity of about 12 feet per second. The water will stand six feet six inches in depth to secure this rating. (See accompanying cross section sketch together with the table of depths, velocities and discharge.)

The accompanying profile map and section of the tunnel indicate more clearly the extent and character of the undertaking.

As stated before, tunnel work was started in the fall of 1906, but progressed slowly, due to various difficulties and many shutdowns. At first it was driven by one shift, and later on two shifts were put at work, in 1907, and finally, in July of that year work was stopped to await the completion of the power plant.

Method of Operation

In 1908, work was again resumed with electric rock drills, but owing to difficulties connected with the machinery, work advanced at a slow pace until the early spring of 1909, when these machines were replaced by Sullivan Class "UF-2" (3¼-inch) Differential Valve Air Drills.

Up to the present time, the tunnel has only been driven from one heading or from the west portal as originally started. The east end of the tunnel is overlain with wet ground and a portion of it is in very soft rock and mud. This wet ground would all be drained by the tunnel, so that if it should be attempted to drive from the east end, it would necessitate the installation of a heavy pumping plant at this portal. The rise from both portals to the rim of the great basin is so rapid that the vertical distance from the tunnel to the surface is too great to make an intermediate shaft practicable, so that it was impossible to drive headings from an intermediate point.

However, due to the rapid progress which has been made since the installation of the Sullivan Drills and also due to the better organization of the tunnel force as the work progresses, driving from only one heading has not involved such a loss

Sullivan drills at the breast, Strawberry Tunnel. Superintendent Davis in center.

in time or expense as at first appeared probable, and the installation of a second plant has not seemed necessary.

Previous to the beginning of the actual construction work, a system of prospect holes was drilled along the tunnel line with Sullivan Diamond Drills, and an accurate record of the cores kept, so that practically all the difficulties of construction were foreseen and arranged for before the work was begun.

Drilling Practice

For advancing the tunnel, the heading and bench method is used. All the drilling is done by two Sullivan Differential Valve Air Drills, "Class UF-2." These machines are mounted in the heading on two double screw columns with adjustable arms. After each machine runner has finished his half of the drilling in the heading round, he turns his machine up on the arm and drills half of the holes necessary for blasting the bench. Thus the entire round of holes necessary for blasting the entire cross section of the tunnel is drilled in one shift and by the same machines.

Mr. J. L. Lytel, chief engineer, describes the method of drilling the holes as follows:

"Usually 16 holes are drilled in the face and two in the bench. (See the accompanying sketch.) The cut holes are drilled 7 feet deep and the remaining holes, including the holes in the bench, average about 6 feet deep. The heading is driven with a bench about 3 feet high, which is being carried from 10 to 12 feet back of the face. The strata in the rock are folded and broken to such an extent that it is not possible to adopt any definite system of drilling.

"The columns that support the air drills are set vertically and generally from 2½ to 4 feet apart, and about 4½ feet back from the face. This gives room for the arms, which support the drills, to be used anywhere on the column. The explosive used is 40 per cent gelatine powder and from 120 to 150 pounds are required to break a round. The holes are exploded with fuse in the order that

they are numbered in the accompanying sketch. The powder is thawed in the thawing house located outside near the tunnel portal. The heat for thawing the powder is furnished by an electric heater, which gives very satisfactory service. No powder is kept in the tunnel, that required for shooting being brought in by the motorman just before the shift is ready to load the holes.*"

Two machines and one complete column are held in reserve to replace either machine or column in the heading which may at any time need overhauling, so that the entire drill equipment necessary for one heading in this tunnel consists of four drills and three columns.

The table on the next page shows the footage made in this tunnel by the Sullivan Drills, operating three shifts per day, in the twenty months from April, 1909, to November, 1910, inclusive. It also shows the number of shifts lost in that time and the reason for their loss.

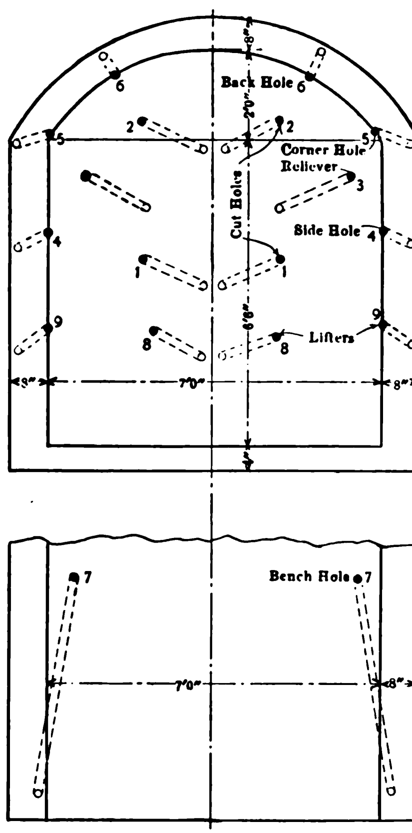
The rock encountered during the time that the above table covers, was practically the same in character, viz. alternate stratas of very hard sandstone with very hard blue limestone. The limestone predominating by quite a large percentage. The air pressure used on this work is about 85 pounds in the heading or as near to that as it can be kept. An air receiver is installed in the pipe line about every 5000 feet, so that this pressure may be very easily maintained without showing much drop between the compressor house and the heading.

DRILL REPAIR COST

The average cost of drill repairs per foot for the completed cross section of the tunnel for nineteen months was 17.2 cents. During the month of October, 1910, when the drills had been in use for nearly two years, a government record was kept of the number of times it was necessary to bring a drill out of the heading for repairs. During the 497 feet of tunnel advance, which was made during

* *Engineering Record.*

Another view of the heading.

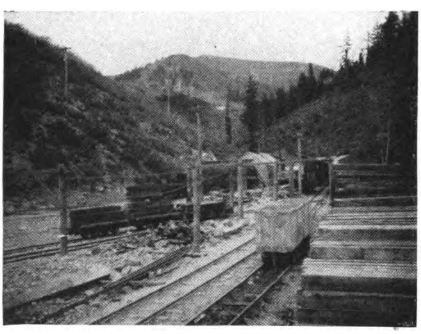


Blast holes in heading and bench.*

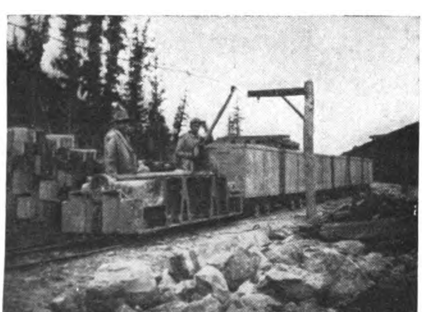
MONTHLY FOOTAGE TABLE

Year	Month	Footage	No. Shifts Lost	Cause
1909	April	407	..	
"	May	262	..	Low footage caused by bad ground, together with water, which required timbering to be carried on the entire month.
"	June	352	..	
"	July	306	21	Account of installing electric haulage, and celebrating 4th of July.
"	August	331	13	Account of bad ground and water.
"	September	370	..	
"	October	391	..	
"	November	387	..	
"	December	344	16	Christmas holidays.
1910	January	425	..	
"	February	407	..	
"	March	354	..	
"	April	389	6	Due to water.
"	May	428	4	Account of building station for blower.
"	June	455	1	Installing machinery.
"	July	377	17	Account of holiday on 4th of July.
"	August	423	6	Account of water.
"	September	439	..	
"	October	497	..	
"	November	500	..	

Total for 20 months, 7844 feet. Average per month, 392.2 feet. Average advance per shift, 5.28 feet.



Tunnel portal and timber yard.



A trip of muck cars.

this month, machines were brought out of the heading only ten times and most of these instances were for replacing packing.

The cost of drill repairs quoted above consists of the actual cost of drill parts, cost of hose, cost of hose connections, cost of all labor connected with the repairing of the machines, and the freight on the parts, which includes a cost of 50 cents per 100 pounds wagon haul from Diamond Switch to Camp Quinton.

It will also be noted that the greatest amount of tunnel advance was accomplished in a month after the machines had been in almost continuous use for a period of nearly two years. Further, an average of over 436 feet of tunnel advance per month has been maintained during the second year of the life of these machines. The above figures may be verified by consulting the records of this work in the files of the United States Reclamation Service.

The total force required for the three shifts, including the executive force, office force, store, barn, cook house, power house, and underground men, is from 90 to 100.

The dump and concrete plant.

HANDLING MUCK

The broken rock is handled in the heading in the ordinary way and taken out in cars holding 4.7 cubic feet, made up in trains, hauled by a 50 horse-power electric locomotive, which weighs about 6,000 pounds.

When these cars reach the dump, they are all dumped by the train crew which hauls them out. This crew consists of two men. The work is accomplished in the following manner. The car bodies are built solid, with two trunnions, one on each end of the car, and so placed, that when the car is loaded the trunnions are beneath the center of gravity, but when it is empty, the weight of the running gear shifts the center of gravity to a point beneath the line of the trunnion. This permits the cars to be automatically handled and dumped by an ordinary electrically operated stiff legged derrick. The derrick used in this case has a capacity of ten tons and is shown in the cut on this page, in the operation of lifting a loaded car.

One leg of the bail which is used for lifting the car is swiveled so that it is free to swing. This facilitates the ease with which it is attached to the car. This leg is also provided with a spring operated pin, which fits a recess in the car above the trunnion. This pin is pulled out of the recess in the car by a short lever. A rope is connected with this lever of sufficient length so that it will reach to the top of the dump when the car is overhanging the point where it is desired to deposit the broken rock, in any particular case. Thus, a loaded car may be lifted from the track by the derrick and prevented by the pin from tipping until it is brought in

Handling cars at the dump.

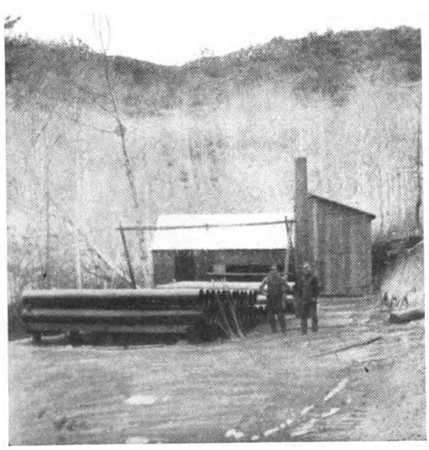
position over the desired point on the dump and then the rope connected with the lever operating this pin may be pulled by the brakeman. Then the car automatically turns over, due to the fact that the center of gravity is above the line of the trunnions. As soon as the car is empty, it automatically rights itself, due to the fact that the line of the center of gravity is then beneath the line of the trunnions.

By this means, the work of at least two men is saved on the dump, without considering the additional safety it gives the men and also the absence of expense due to cars going over the dump.

The derrick is mounted on wheels so that it may be run on a track; when it is necessary to extend the dump from time to time, the derrick may be easily moved ahead by simply extending the derrick track. It has been found necessary to move this derrick about once a month and this is accomplished by six men.

VENTILATION

The tunnel is ventilated at the present time by a forty horse-power Root blower capable of handling 3000 feet of air per minute under a pressure of two pounds per square inch. This blower is placed at the present time in a station 5,000 feet in from the portal, so that it draws on one side and pushes on the other, through a fourteen-inch ventilation pipe.



Ventilating pipe station.

This blower at the present time is run full speed for 26 minutes after each blast and at half speed the balance of the time. Under these conditions, air tests show about six to ten parts of carbon dioxide gas in 10,000 parts of air, which is about what a well ventilated school room will show.

The ventilation pipe is put together, tarred and riveted in 16-foot lengths, in a separate plant, maintained for that purpose at the tunnel. The manufacturer simply rolls and properly punches this pipe, then it is nested in four foot lengths and shipped in that manner. This greatly facilitates the handling of the pipe, both on the railroad and also by the freighters on the long haul from Diamond Switch to the tunnel. In addition the ventilation plant maintains itself on the reduction in the actual cost of the pipe.

SURFACE EQUIPMENT

A complete stone crushing and concrete mixing plant has also been recently constructed and installed at the west portal of the tunnel. This building is shown in the foreground over the dump in the cut on page 489. The plant is used in the process of constructing the concrete lining of the tunnel. Concreting began in September. During November, 563 lineal feet of tunnel were lined, and over 4,500 lineal feet have been completed up to the present writing.

The power plant at the west portal consists of the necessary transformers for stepping down the voltage of the transmission line; a motor generator set for converting the current from alternating to direct current, which is used in the locomotives, derrick, and machine shop; a 15 x 9 x 12 power driven air compressor, driven by belt from an induction motor.

The carpenter shop maintained at the

Sixth Water Valley, down which the water will flow.

west portal is equipped with an electric planer, band and crosscut saws.

The machine shop is equipped with a drill press, lathe, pipe cutter, and emery wheel.

Where it is necessary to use timbers, a uniform timber section is maintained, which is shown in the cut on page 485. The timbers used are eight inches by eight inches and placed on four foot centers. The trolley line into the tunnel, instead of being suspended from the roof or the timbers as in ordinary cases, is hung from separate poles, so that as soon as concreting is begun, this work may be continued without interfering with the trolley wire. A 25-pound rail is used for the track.

The cost of excavation for the month of November, 1910, is furnished by Mr. Lytel in the following table:

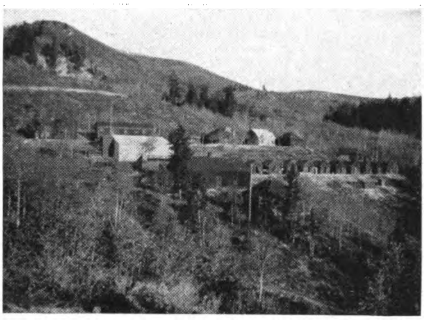
*Cost of Excavation for November, 1910.—Heading From West Portal. (Advance During Month, 500 Feet.)

Classification.	Cost Per Lin. Ft.
Labor.	
Engineering	$.500
Superintendents	.500
Shift bosses	1.308
Timekeepers	.100
Drillmen	2.843
Miners	.187
Muckers	2.860
Track and dumpmen	.536
Skinners	....
Timbermen	.609
Miscellaneous	.087
Materials.	
Powder, fuse and caps	3.009
Lumber	.413
Oils, candles	.230
Vent. pipe	.720
Track and ties	.523
Air pipe	.219
Drill repairs	.014
Miscellaneous	.040
Machine shop expense	.899
Blacksmith shop expense	.988
Corral expense	.088
Power	3.763
Depreciation, tramway plant	.200
Labor.	
Motorman and brakeman	1.080
Electrician and blowerman	1.43
Disabled employes	....
Equipment depreciation	1.000
Camp expense	.545
General expense	3.292
Total per lin. ft	$26.696

* Engineering Record, April 22, 1911.

A hospital is maintained and a doctor is constantly available at the camp. A government store for general supplies and groceries is maintained for the convenience of the workmen and their families. For the use of the men during recreation hours, a reading room and also a hall provided with billiard and pool tables are maintained by the government.

Instead of arranging the sleeping quarters for the single men in one large bunkhouse, it has been found much more



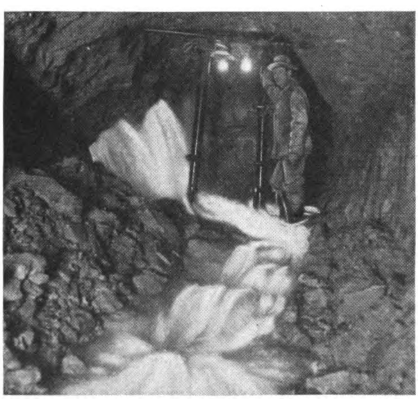
Tunnel camp and houses.

satisfactory and also much more sanitary to build a number of small houses, some of which only accommodate three or four men, while others provide quarters for ten to sixteen. For families, separate houses are built. A general view of the camp and these buildings is shown in the cut above.

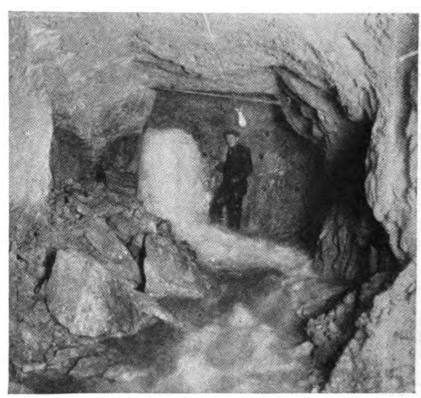
The entire project was 46 per cent completed at the close of March, 1911.

The writer wishes to express his obligations to Mr. J. L. Lytel, the project engineer in charge, and to Mr. W. H. Davis, the tunnel superintendent, for their courtesy and assistance rendered in obtaining the necessary data for this article. Also, for the favors extended by members of the engineering staff.

Editor's Note: This article was prepared for use in the February issue of MINE AND QUARRY, but was omitted owing to lack of space. The rapid progress of the preceding months was continued in December, working three shifts, until the 27th, when a flow of water amounting to six cubic feet of water per second was struck in the heading, preventing excavation for the remainder of the month. The total for December was 342 feet in 65 shifts. Since that date, the flow of water has settled down to a steady outpour of from seven to eight second-feet, as shown in the illustrations on this page. In January 150 feet of tunnel were driven, in February, 214 feet, in March 290, and in April 194 feet. The tunnel was 42 per cent completed on April 1st. The flow of water during April averaged 7 cubic feet per second.



Just after striking the water.



What "seven second-feet" means in a tunnel breast.

HAMMER DRILLS IN QUARRIES

Sullivan DB-19 hand feed hammer drills are used extensively in quarry drilling requiring holes not over five feet deep or more than 1¾ inches in diameter. In a Pennsylvania limestone quarry, where the stone is hard, but chips readily, eight of these tools are used. Four-foot holes have been drilled in 18 minutes, and on a test, 14 inches were drilled in 4½ minutes, or 3.294 inches per minute. These drills employ hollow steel and deflect exhaust air through it to clean the hole. No trouble from sludge is encountered in drilling holes five feet deep. Sharp bits were found to cut three inches more than dull ones in a run of 4¼ minutes. A 3¼-inch Sullivan rock drill has accomplished 80 feet of 12-foot holes in this rock in nine hours.

At an Ohio quarry, blocks of soft sandstone about eight feet square are cut by hammer drills which put in holes in a long line. With a Sullivan "DB-19" drill, 20 holes 18 inches deep have been sunk at a rate of 25 seconds per hole. Competing tools required five to ten seconds longer.

Block holing in crushed stone quarries is another important function of hammer drills. A few years ago, an air compressor and Sullivan "D19" tools were substituted for hand labor at an eastern quarry. It had previously required 18 hand drillmen to do this work. The manager found that six tools, with one man on each, could do as much as the 18 hand workmen. The rock at this quarry is very hard granite, not unlike the "trap" of Bergen Hill, Jersey City, N. J. The holes drilled in the rock fragments averaged 18 inches deep, although some ran to 36 or even 48 inches. Hollow steel was used, sharpened with a cross bit, and the air pressure averaged 80 pounds. The cutting speed ran as high as 2½ inches per minute, but averaged one inch per minute. The saving per day secured by the drills over hand labor may be summarized as follows:

Sullivan hammer drills. Block holing.

18 hand drillers at $1.50.		$27.00
6 hammer drillmen at 1.50	$9.00	
Air Compressor operator at	3.50	
One ton of coal..........	3.00	
Repairs per drill.........	.60	
Oil, etc.................	.30	
Interest on plant.........	.60	17.00
Saving per day..........		$10.00
Saving per year of 200 days		$2,000.00

This was about the cost of the plant. The blacksmithing is not included in this estimate, as it was about the same for both the hand and hammer drill steels.

Sullivan pick machine.

AN UNDERGROUND COMPRESSOR PLANT

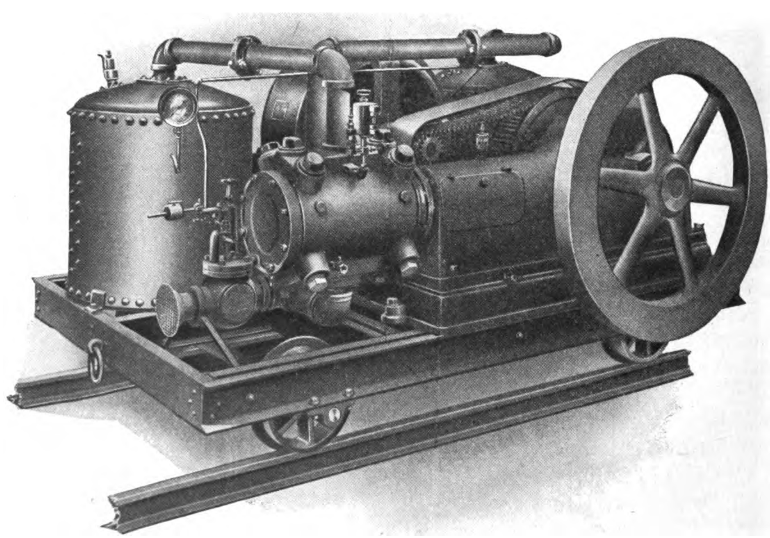
In the September, 1909, Mine and Quarry, appeared a description of an electric driven air compressor, mounted on a mine truck, for use when a portable electric-air unit is preferable.

An outfit of the nature there described has been in satisfactory use for nearly a year at the Midway Mine of the Chicosa Fuel Company, at Rouse, Colorado. It consists of a Sullivan "WK-2" single stage compressor, connected by silent chain drive to a direct current electric motor, and mounted, with its air receivers, on a substantial steel car or truck. The compressor is fitted with an unloading device, and is of the center crank, enclosed frame, splash lubrication pattern.

The outfit is set in a niche or station, cut in the coal at the side of the entry, and supplies power to two Sullivan direct acting pick machines, which are used in cutting rooms and driving entries. The compressor is started at the beginning of a shift by a pump man, who is stationed a quarter of a mile from it, and no one goes near the machine again until the end of the shift. The unloading device reduces waste of power when the punchers happen to be idle. The air is supplied at 80 pounds' receiver pressure, and runs through about 800 feet of two-inch pipe. It is then split and is carried to the machines by two one-inch pipes, about 400 feet long each. The machine will in future be kept nearer the working face, however.

The two pick machines cut an average of 80 to 100 lineal feet of face per day. Since they were installed, the percentage of lump coal has increased about 20 per cent, as compared with that produced when the coal was won by shooting off the solid. Rooms are now being worked, with the punchers, which could not be touched before, because of bad roof. Attempts to shoot from the solid in these places usually resulted in blowing out the props, and the whole roof then caved in.

The use of the Sullivan "WK-2" compressor outfit at this mine has resulted in important economies in attendance, power, and plant, since a compressor at the surface would have entailed a length and cost of piping which would have been almost prohibitive.



Sullivan WK2 air compressor.

THE AUTO TRACTION ROCK DRILL

A NOVEL BORING TOOL FOR DEEP BLAST HOLES

By George H. Gilman[1]

In crushed stone quarries and in many engineering undertakings, economical rock excavation requires the drilling of deep blast holes, of large diameter, to accommodate heavy charges of explosive. These holes, in current practice, range in depth from 15 to 50 feet, and from three to five inches in diameter at the bottom. They are drilled principally with large tripod drills, from 3⅝ to 5½ inches in cylinder diameter, with a derrick or tripod of wood or pipe to handle the heavy steel, as shown in the cut on this page.

Three difficulties arise in using machines of this pattern. They are cumbersome and hard to move from one hole to another. Much time is lost in changing drill steel, since the range of feed does not exceed 2½ or 3 feet; the deep holes are hard to keep free from mud and sludge, so that the force of the drill's blow is partly lost by cushioning on mud instead of striking fresh rock at each stroke. The result of these handicaps is that a comparatively small proportion of the total working time is spent in actual drilling.

Two of these difficulties, those of transportation and of changing steel, have been solved by the use of traction well-drill outfits or churn drills. These machines have been employed with some success in railroad work in Pennsylvania and in the Canadian Northwest, on the Panama Canal, and elsewhere. The difficulty of cleaning the holes persists in this type, and is a considerable impediment to efficient work.

It was with these considerations in mind that Mr. C. H. Locher, of the engineering firm of Grant, Smith and Company and Locher, undertook, about two years ago, to devise a blast hole driller more rapid and efficient than any machine then available.

[1] Claremont, N. H.

Drilling deep holes with a heavy tripod drill and movable derrick.

THE LIVINGSTONE CHANNEL

Grant, Smith and Company and Locher are contractors, under the United States government, for the excavation of the Livingstone Channel, in the Detroit River, between Amherstburg, Ontario, and Grosse Ile, Mich. This channel will be 300 feet wide and about one mile long, with a normal depth of water of 21 feet. The area was first enclosed by cofferdams and pumped out, then steam shovels and traveling cableways removed the overburden in the usual manner, leaving a rock cut to be made from 12 to 20 feet in depth. It may be mentioned in passing that this area was drained in record time by an invention of Mr. Locher's. A battery of air lift pumps was constructed by means

General view of work on the Livingstone Channel, Detroit River. Channeled w

of long sections of 8-inch pipe, laid side by side at an angle of about 45 degrees and reaching from the bottom of the water over the edge of the cofferdam. These were connected with air piping, compressed air turned on, and the water fairly blown out of the enclosure.

NATURE OF DRILL WORK

The walls of this rock cut are being channeled in one or more lifts, as occasion requires, by two Sullivan "Y-8" steam driven channeling machines, and two 8-inch channelers of another make. The rock between is then drilled by 3¼-inch tripod drills driven by air, and broken by blasting to sizes suitable for the shovels and conveyors. With these drills, an average eight-hours' work, including all delays, moving from hole to hole, et cetera, is about 40 feet of three-inch hole. The rock is a soft limestone, turning to dolomite with depth, and easy to drill, except for the presence of joints and seams, which tend to throw the holes out of alignment and make proper "mudding" or cleaning of the holes rather difficult.

THE NEW IDEA

The machine which Mr. Locher has invented to replace the tripod drills, is shown by the photographs on the front cover, and on pages 498 and 501. It consists of a vertical standard or carriage, carrying a rock drill cylinder attached to a heavy iron block, which is suspended in guides or ways over 20 feet in length by a steel cable, which passes over a sheave and is alternately paid out or taken in, as needed, by a hoisting drum. The standard and hoist are mounted on a steel wagon truck. A two-cylinder reversible engine provides power for the hoist and for moving the outfit from place to place, by means of a chain drive to the axle of the rear wheels, above which the standard is mounted. The front wheels swivel to permit steering. The truck carries an air re-heater or a boiler as required, and jackscrews are provided at the rear end for taking up motion while drilling is in progress.

It will be seen that this outfit enables holes to be drilled to a depth of 20 feet without change of steel, and in this rock,

in background; a channeler, housed for winter use, is working on the left wall.

it is possible to drill 100 feet without materially dulling a bit or wearing the gauge. The traction feature cuts down to a few seconds the time required for changing from one hole to another. The work of cleaning the holes is accomplished by an entirely new device, which will be described before telling the nature of the performance done with this outfit or explaining its details of construction.

LOCHER PUMP STEEL

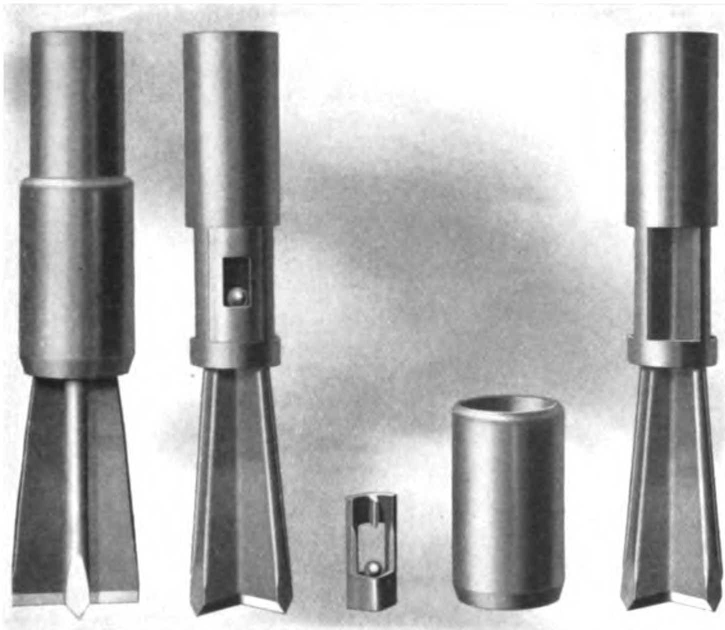
When drilling in this "blocky" formation the chief difficulty encountered with the tripod drills, as noted above, was the extraction of cuttings from the hole as the depth increased. This was due not only to the broken condition of the ground, but seams were often encountered which led to the opening made by a previous blast, so that it was practically impossible to properly "mud the hole." After many devices and special kinds of steels had been tried without success, the idea of using the movement of the drill steel for direct pumping suggested itself, and upon trial gave good results. The scheme employed for this purpose consists of an ordinary drill steel, cruciform in section, over which is shrunk a tube. The bottom end of this tube is made in the form of a cage, carrying four ⅝-inch steel balls, which act as valves. A sectional view of this device is shown on page 499. When the drill steel is thrown forward, these balls are raised from their seats by the resistance of the mud in the bottom of the hole, and a quantity of the sludge is thus thrown above them. When the steel lifts, these balls are naturally dropped to their seats, thus preventing the entrapped sludge from escaping, and the rearward stroke of the drill is sufficient to throw the cuttings out of the top of the tube, where they are deflected downward by a saucer shaped plate securely fastened to the shank of the steel.

Difficulty was at first experienced in securing the tube to the drill steel. This, however, has been largely overcome by rolling the steel with corrugations into which the tube is rolled by a special process. The valve cages are then inserted in openings cut in the lower part

Auto traction drill at the Church quarry.

of the tube directly opposite the grooves in the steel, and are held in position against unintentional displacement by an outer sleeve. With this device no difficulty was encountered in cleaning the hole of cuttings and even in broken ground little trouble was experienced in keeping the bit free.

When drilling with this arrangement, it is absolutely necessary to have a good stream of water running into the mouth of the hole. To prevent the cuttings from finding their way back into the hole, it is customary to use old sacks, held in place about the mouth of the hole, by stones.



PUMP STEEL.

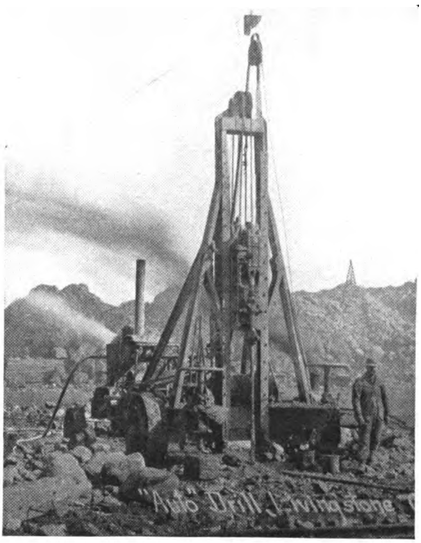
1. **Steel complete.**
2. **Steel with outer casing removed, showing cage and ball.**
3. **Cage and ball.**
4. **Outer casing.**
5. **Steel with tube, ball and cage removed.**

To clean the hole after it has been drilled to the required depth, preparatory to loading for firing, or to regain the proper alignment in a deflected hole, it is merely necessary to throw the drill on to a cushion provided for this purpose and described later. It will then reciprocate for nearly a full stroke without striking either head, and thus pump out any loose material which may remain in the hole. This system of drilling has been patented by Mr. Locher in both this and foreign countries.

EXPERIMENTAL RIGS

The outfit illustrated on pages 498 and 501 was not perfected all at once. In fact, it is the third of this kind which has been built to Mr. Locher's plans. The first rig was built of heavy timbers and carried a drill five inches in diameter, in guides providing a travel or depth of hole of eight feet, without changing steel. This served its purpose admirably, for it demonstrated that an arrangement of this kind was practical.

In drilling to the required depth, however, two changes of steel were needed for each hole, and the time required to make the changes was found to be a large percentage of the total consumed in bottoming each hole. It was furthermore found that by drilling larger holes a given amount of rock was broken to steam shovel size with fewer lineal inches of drilling, and that there was a marked saving in the amount of powder used.



Auto traction drill with Sullivan "UM" drill and 14-foot feed.

EARLY CUTTING RECORDS

In spite of these handicaps, this first machine, crude as it was, worked steadily for several months, and made some interesting records. On one occasion, 29 feet of three-inch hole were drilled in 55 minutes, including four moves, occupying about 45 seconds each. In an hour's run, with dull steel and low air pressure, 37 feet 3 inches of hole were drilled, with five moves. In 32 minutes, three holes were drilled, 6 feet 2 inches, 7 feet 2 inches and 7 feet 2 inches deep, and the rig was moved three times. The first of these three holes was drilled in 5¼ minutes. Moving, from the time one hole was finished, until the next was started, occupied just two minutes.

THE SECOND OUTFIT

This success led Mr. Locher to design and build another machine of more substantial construction, with a 14-foot feed, on which was mounted a Sullivan "UM" drill, with a piston seven inches in diameter, capable of drilling holes to the required depth with a five-inch bit. With this machine remarkable work was accomplished, and a drilling speed of 12 lineal inches per minute with a bit of this size was by no means an uncommon occurrence.

SOME FAST DRILLING

In July, 1910, this machine worked 28 eight-hour shifts and put in 3,282 feet of holes, averaging 11 feet in depth. This gives an average speed of 117.2 feet per shift, of holes five inches in diameter, as compared with 39 feet per shift for the 3¼-inch tripod drills, drilling three-inch holes as mentioned above. So that the auto-traction drill actually put in three times as many lineal feet of holes as the tripod machines, and these holes were nearly three times as large in area as those bored by the old type of drill.

The 28 shifts included 31 hours of lost time, moving away from shots, changing water lines and other delays caused by limited space, low working faces, et cetera. Seventy-five feet were drilled in three hours, 165 feet in 7½ hours, and 145 feet per day for five consecutive eight-hour shifts.

It may be noted at this point, to emphasize the economy in time of long runs without changing steel, that a Sullivan 3⅝ drill, mounted experimentally on a quarry gadder standard, bored 594 feet of three-inch hole in six days. The length of the standard permitted holes six feet deep to be drilled without change of steel. The machine was new and the men unused to handling it. Both this and the auto traction drill records mentioned above, were made with the use of the pump steel. The following detail record shows the saving in time accomplished by the use of the pump steel, and by increasing the length of the feed:

On October 26, 1911, two sets of records were taken. The first was made with a Sullivan "UH2" 3⅝-inch drill, mounted on a gadder frame, with a small hoisting engine to raise and lower the

steel, and pump steel. The leads permitted holes to be drilled six feet deep without changing steel.

Hole No.	Depth, ft.	Changing Steel Min.	Drilling Min.	Total Min.
1....	8	6	12	18
2....	8	5	8½	13½
3....	8	3½	9	12½
4....	8	4	12	16
5....	6		10	10
Total..	38	18½	51½	70

Six holes were then put in by the same drill, using regular steel, and pumping the holes by hand. The regular feed screw, two feet long, was employed, so that the steel had to be changed once in 24 inches.

Hole	Depth ft.	Drilling Min.	Total Min.
1............	8	14½	42
2............	8	24	52
3............	8	14	22½
4............	8	18½	27½
5............	8	13	32
6............	6*	42	49
Total..........	46	126	225

The time for moving from hole to hole was not considered in either case. It will be noted that if the length of feed in the first record had been eight feet instead of six, 18½ minutes would have been saved in drilling 38 feet.

It will be seen from these two records that with the pump steel and long feed, the rate of drilling was one foot in 1.35 minutes, with the regular steel and usual feed (ordinary tripod drill methods) one foot in 4.89 minutes. That is, with the same labor and in the same time the improved method accomplished 3.62 times as much work as the old or standard method.

A DRILL WITH 20-FOOT FEED

In the summer of 1910, work was encountered which necessitated the drilling of holes to the depth of 20 feet. Mr. Locher decided to have built a new machine incorporating all the features which were found to be advantageous in the earlier machines, including a vertical

* Bad hole.

Auto traction drill; the steering end.

range of feed for the drill exceeding 20 feet, and capable of drilling five-inch holes at the rate of 12 inches per minute in the limestone of the Livingstone Channel.

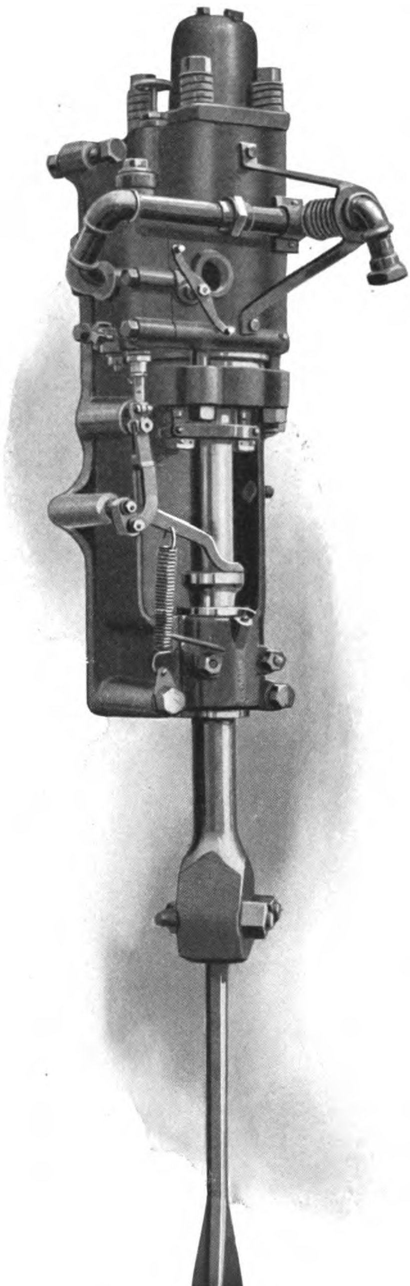
The order for this outfit was given for execution to the Sullivan Machinery Company, and the machine was delivered late in the fall of 1910.

CAPACITY AND DIMENSIONS

This outfit is capable of drilling holes to a depth of 50 feet. The mounting is arranged to move backward or forward at a speed of 20 feet per minute. The hoisting speed for raising the drill and weight is 30 feet per minute. The rig stands about 31 feet high, is 21 feet long and 12 feet wide, and weighs 33,000 pounds.

FRAME AND CARRIAGE

A brief description follows: The horizontal frame, built entirely from



Sullivan "UM" rock drill.

structural steel, is mounted upon four wide-tread steel wheels, those in front being swiveled for steering, while those at the rear are on a fixed axle. A drive shaft, geared direct to the engine through jaw clutches, carries two small sprockets on either side, which are connected by a sprocket chain to larger sprockets secured to the rear or driving wheels for moving the outfit. Directly over the rear wheels is the vertical standard, composed of channel irons, securely braced to the frame of the machine, and serving as a guide for the drill. Forward of this, mounted upon the frame, is the hoisting and propelling mechanism with its two cylinder, reversible engine, while over the front wheels is mounted an air re-heater, through which the compressed air passes to supply both the engine and drill. It will thus be seen that the greatest weight is directly over the rear drive wheels. Jack-screws are provided at the rear of the frame, which may be set down upon the rock to give the entire machine stability in a lateral direction while drilling is in progress.

HANDLING THE DRILL

The feeding of the drill is accomplished entirely by a suspended weight, to which the drill cylinder is bolted and which provides stability for it. A slow retrograde movement of the hoisting drum for lowering is given by worm gearing, while the hoisting is accomplished by a train of spur gears which connect the main shaft of the engine, through a jaw clutch, with the hoisting drum. An automatic locking arrangement is provided between the hoisting drum and its gear, which prevents any possibility of the drum slipping. With the worm gear in mesh, both hoisting and lowering may be accomplished on the slow speed, while with the spur gears, the drill may be hoisted only. No brakes of any description are employed and the speed at which the various devices operate is controlled entirely by the engine throttle The engine runs

continuously while the drill is being fed at any desired speed. Every movement of the entire machine is controlled by a bank of levers from the operators' platform at the rear, and located in such a way that each is accessible and convenient for the operator. One of these levers controls the power steering mechanism, by which the course of the outfit is directed when in motion.

When starting a hole the drill steel is guided by a hinged clamp fastened to the lower end of the standard, and through which the drill rod reciprocates. After the steel has cut to a depth slightly over the length of its stroke, this clamp is disengaged and swung out of the way, where it remains until the hole is bottomed.

A davitt, with block and tackle, at the top of the standard, provides for handling the long lengths of drill steel, in connection with a winch on the main shaft of the hoisting engine.

ROCK DRILL PROPER

The drill proper used with the Sullivan auto traction drill is an entirely new development in rock drill practice. The cylinder is seven inches in diameter, with a piston stroke of 8⅝ inches. Important changes have been incorporated in it to handle the heavy lengths of steel, and to secure at once, speed, economy of power, and adaptability to the rock and other working conditions. It may be described as a combination of the standard drill and the chopping engine of the Sullivan direct acting channeler, which has been in satisfactory use for many years.

The channeler valve and piston motion have been adopted, to secure economy, by using the air or steam expansively. The main valve is air-thrown, but is controlled by a reverse valve mounted on the stem of a cut-off valve, which in turn is actuated by a lever in direct contact with the piston, so that the point of cut-off and the length of the stroke may be automatically regulated. Corliss valves in the exhaust ports provide a cushioning effect and prevent damage to the cylinder head in case the drill should run into a mud seam or pocket.

The usual method of rotation is employed, except that instead of boring out the piston to make provision for the rifle bar the rifle bar is made a part of the piston proper by cutting the flutes upon a projection from the rear of the piston head. To eliminate cylinder wear, a guide bearing for the rod is provided by an extension from the cylinder proper, carrying a removable bronze bushing through which the piston rod reciprocates. This is one of the most valuable features about the machine, as it reduces cylinder wear to a minimum. This wear would otherwise be very pronounced when handling the long lengths of steel.

The drill is lubricated by an automatic oiling device, located in the upper head, controlled by the pulsations of the air in the cylinder. The chamber holds about one quart of oil.

PERFORMANCE

The photographs of the outfit at work were taken in the crushed stone quarry of the Church Quarry Company at Sibley, Michigan, where it was installed temporarily, pending the resumption of the government work at Grosse Ile this spring. At Sibley the auto traction drill has fully justified the experiment, which resulted in its construction. It has drilled holes to a depth of 44 feet in rapid time, and the pump steel is entirely successful in handling sludge from holes of this depth. It is estimated that as a means for breaking ground, this outfit, run by two men, will do the work of five tripod drills, requiring ten men for their operation, and that it will accomplish a considerable saving in powder, owing to the larger diameter of the holes drilled. The economy in motive power is also an important factor.

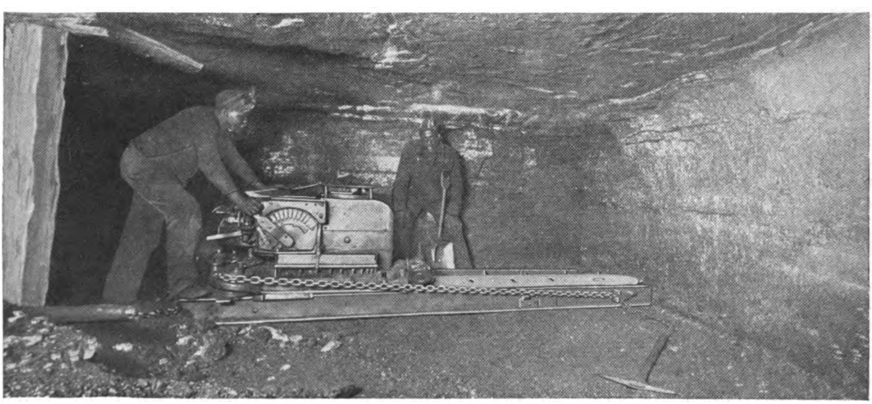
The writer's acknowledgments are tendered to Mr. C. H. Locher for data and suggestions in connection with this article, and for courtesies in securing photographs.

POWER REQUIRED FOR COAL CUTTERS

The United States Coal & Coke Co., with mines at Gary, West Virginia, employs about 75 Sullivan continuous cutting electric chain machines, undercutting to a depth of 6½ feet and 5½ inches high. The voltage is 250 (D. C.). At the June, 1910, meeting of the West Virginia Coal Mining Institute, Mr. Eli Clemens, chief electrician of the company, read a paper entitled "Electricity as used in the Modern Coal Mining and Coke Making Industry," from which the following paragraphs are quoted, referring to the Sullivan machines:

"Since electric drive is fast superseding steam driven tipple machinery and pumps, and coal is being undercut, shot down and transported, it may be interesting to those who have electrically operated plants and not the facilities to make tests, to those who are contemplating changing from steam to electric drive, or to those that are considering putting in new machinery entirely, to know the amount of power used by some of the various appliances used in a modern electrically operated coal and coke operation.

"From tests we have made, the chain undercutting machine which we are using almost entirely, we will consider first. This is a self-propelling machine. It cuts under the coal and then travels across the face of the room or heading. Any width of room can be cut, by resetting jack pipes and chain. From a series of tests we have made at several of our mines, covering 25 places cut under average conditions (no effort was made to get ideal conditions, but simply conditions we meet daily), we find that an average of 380.4 watt hours are used for propelling 453 feet, and the time required is twelve minutes and two seconds; that 143.3 watt hours are used for unloading machine in ten minutes and fifty-six seconds; that 2412.4 watt hours are used to undercut coal, the average size of undercut being fourteen feet and eight inches wide and averaging 78.27 square feet, and eighteen minutes and ten seconds were required for this operation, or about 30.82 watt hours per square foot undercut, and it also required 382.8 watt hours in eighteen minutes and thirty-nine seconds to load machine, or a total of fifty-nine minutes and forty-seven seconds and 3318.9 watt hours per place to load, move, unload and cut. With coal averaging six feet in height and weighing eighty-two pounds per cubic foot on the solid, approximately 19.25 tons per cut were obtained."



Sullivan continuous coal cutter making rib or sumping cut. After this cut is finished the rear half of the frame is removed, and the machine crosses the face at one operation.

THE ROSICLARE LEAD AND FLUORSPAR MINING COMPANY

By R. S. Hutchison [1]

The largest fluorspar mining operation, as to both output and equipment, may be found in Southern Illinois, on the banks of the Ohio River, at Rosiclare. Hampered by not having direct railroad facilities, and depending on the river as a means of transportation for the removal of the "spar," Rosiclare has nevertheless developed into an important mining town; and by earnest effort in the spar industry, now boasts the most complete and modern plant in the world.

About 1835 the first shaft was put down at Rosiclare and spar mined and shipped. Since then operations have continued intermittently until the present. The largest output of the old operation was in the neighborhood of 25 tons per ten hour day, while to-day 500 tons are produced in the same length of time.

OCCURRENCE AND USES OF SPAR

In the Southern Illinois field fluorspar occurs in veins ranging from a foot or less to 20 feet in thickness. It lies between walls of limestone and quartzite, although considerable calcite, locally known as "calc," also appears in the wall formation. The Rosiclare vein is almost vertical, but there is enough of a dip to call the east wall the foot wall, and the west wall the hanging wall. Fluorspar is classified for the market as lump, gravel, and ground. It has three general uses. The highest grade, which may attain 98 per cent in fluorite, is used principally in chemical work. The next grade is used in enamelling and in the manufacture of glass, porcelain, and similar products, while the third grade is used principally in the smelting of iron and in the manufacture of steel by the open-hearth process. This last use is really in its infancy, as it is only within recent years that iron and steel manufacturers have begun to realize the economy to be gained in their processes by using spar.

[1]St. Louis, Mo.

THE MINE

The shaft of the Rosiclare mine is 225 feet deep. It is only a short distance from the original one put down after the discovery of fluorspar. It has two compartments with a pump way, and is timbered throughout. A main haulage drift runs north and south from the shaft bottom and extends about 1,000 feet in each direction on the vein. This drift is approximately six by seven feet in size, depending on the spar encountered. Aside from the main level two intermediate levels are used to develop the ore body. These are 75 and 150 feet above the main level and are reached from it by raises. Both the 75 and 150 feet levels are driven on the vein and both are being stoped out, all the ore being conveyed by cars or wheelbarrows to the ore chutes,

Sullivan stoper at work.

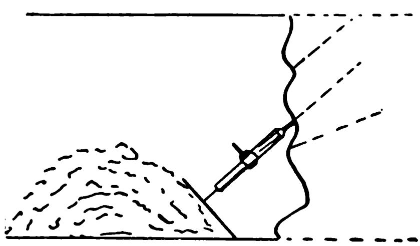


Fig. 1. Drilling upper holes.

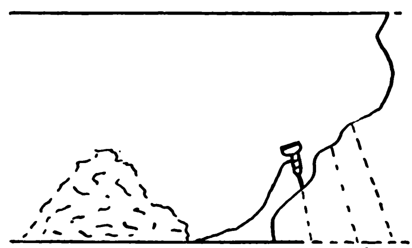


Fig. 2. Drilling down holes.

which empty into the haulage cars on the main drift. The raises are carried about four by six feet, and are driven by Sullivan stoping drills. These tools have here maintained their reputation for speed, and among those who have used them are classed as being the "cuttinest drill that ever went into a stope." One runner has put in nine holes, five feet deep, in one hour and forty-five minutes in this work. Two methods are employed in driving the drifts: (1) with rock drills mounted on columns, and (2) by means of a "drifter," which is a stoping drill using hollow steel instead of solid bits, and a sinker or hand feed hammer drill. With the rock drill, from nine to 14 holes constitute a round. The ground breaks short and the holes "gun" badly, so that the rate of progress is slow compared to driving in ordinary limestone formation. The average advance with this machine has been about 50 feet of drift per month (single shift).

In the second method referred to, viz.: with the "drifter" and "sinker," the miner advances his working face almost as fast with the column drill. Generally, three rows of holes are placed in the face, some almost horizontal, and others pitched as much as 45 degrees above horizontal.

Fig. 1 illustrates the general plan for the holes put in with the "drifter." These holes are shot and the remaining bench, as shown in Fig. 2, is then drilled with the "sinkers" and shot, leaving practically a square face once more.

To drill the holes shown in Fig. 1, the feed piston is placed against a block or piece of plank, supported by the muck pile. Sullivan "DB-19" hammer drills, weighing about 40 pounds, are employed as sinkers. All the mining proper is done on a contract basis, the price being set on footage. This system, however, is now being changed to a tonnage basis.

MILL AND TREATMENT OF ORE

The mill is original in design, and is operated almost entirely by gravity. The spar is hoisted from the shaft to an elevation of 80 feet. It is dumped over a grizzly of novel design or else directly into the hopper of a gyratory crusher of 300 tons capacity.

All lump spar sorted out as an over-size from the grizzly is placed on steel apron conveyors that carry it to a cylindrical dryer, where it can be drawn off into a 300-ton steel bin for direct loading as lump shipment; or the lump spar from the dryer may be drawn off into a modified form of "Edison Tower," thence to a smaller gyratory crusher which crushes to one-half inch size. This is passed on to the grinding mills, and after being reduced until it will pass through a 40-mesh screen, is carried by a spiral conveyor to storage bins and from there shipped in barrels or packages.

The undersize from the grizzly referred to, which will pass a 2½-inch ring, as well as the product of the first crusher mentioned, which is set to crush to 2½ inches, is gathered in huge steel pyramidal hoppers, which have a joint capacity of 300

tons. From these bins the spar is drawn off into oscillating, rectangular, inclined screens. The under-size from these two screens passes by gravity directly into a 200-ton jig. The 2½-inch over-size passes to a steel apron picking-table where the rock is picked out and stored away for tram road ballast. Calcite is also picked out and thrown into storage bins for commercial disposition.

Finally, high grade zincy stuff and high grade leady stuff is sorted out and cast on a Zimmer double compartment conveyor underneath the picking table. Each of these ores is carried by the conveyor into separate 13-inch disc crushers, which reduce both to a six-millimeter comminution. Thus finally reduced the products pass to separate four compartment Richards jigs. The residue on the picking table is crushed to one-half inch and joins the Zimmer screen undersize and flows by gravity to the 200-ton rougher jig. Besides the above mentioned jigs the concentrating room is provided with a 200-ton cleaner jig; both of these jigs are operated on a unique system worked out especially for the problem at hand. They are expected to recover and finish for market use all lead values in the dirt they receive, and also to recover but only partially finish nearly all the zinc values in the dirt the jigs receive. Of course, the jigs are expected to finish and clean fluorspar "grand" for the market. The concentrating room is fitted with every modern accessory necessary to handle the proposition involved.

POWER PLANT

There are four boilers with a total of 700 horse power, all of which are under mechanical forced draft. A water softener has been installed and is giving satisfactory results. There are two 125 K. W. generators and one 75 K. W. generator, all steam driven. When completed the plant will have approximately 1,500 feet of air.

The writer is indebted to Mr. A. H. Reed, Superintendent and Engineer in charge of the Rosiclare mine, for privileges extended and assistance rendered in preparing this article. The whole plant is the result of peculiar conditions which have been overcome by special designing and engineering, for which Mr. Reed deserves much credit.

CHANNELING IN NEW YORK CITY

REPRINTED BY REQUEST FROM THE AUGUST, 1906, MINE AND QUARRY WITH REVISED COSTS

BY JOSEPH H. BROWN, JR.[1]

A problem which has long vexed engineers and contractors of New York City in excavating for new buildings, railway cuts, etc., is that of removing rock without disturbing adjacent foundations. To accomplish this by cutting the side walls with track channelers has frequently been declared impracticable, but the success of the Sullivan Channelers on the New York Central cut under Depew Place in 1906, conclusively proved the practicability and superiority of this method.

The construction of the depressed yards for the new terminal of the New York Central and H. R. R. Co., at 42d St., by Butler Bros.-Hoff Co., the contractors, involved the excavation of Depew Place for its full width of 50 feet between 42d and 44th Sts., a distance of about 500 feet. Below the natural soil and fill, which extended to a depth of from 15 to 25 feet, lay the ordinary gneiss rock, sloping downward to the west at an angle of about 30 degrees, though in some places the top was apparently level. The surface was uneven and the stratification broken and irregular. The average depth of rock to be excavated was about 15 feet, and the

[1] 30 Church St., New York.

Sullivan "Y-8" channeler excavating the subgrade terminal yards of the New York Central Railroad, at Forty-second Street, New York City.

total amount, approximately, 18,000 cubic yards. On one side of the street the baggage room extended the full length of Depew Place, and upon the opposite side was the Grand Central Palace, 200 feet in length.

On account of the proximity of these foundations to the line of the cut, the contractors found it impossible to blast without first freeing the rock at the side. This left them the option of making these wall cuts by drilling and broaching or by channeling. After figuring over the costs and estimating the rapidity of the two methods, they decided to adopt Sullivan stone channelers, and installed two Class Y machines with 8-inch cylinder, operated by compressed air, and fitted with air reheaters. The steel used was the solid Z-shaped type. The cuts were made in two, and in some places in three lifts, varying from 6 to 9 feet in depth. The illustration shows the channeler at work on the first cut.

These channelers frequently cut as high as ten feet an hour in the irregular gneiss formation, which is one of the most difficult in which channelers have been used. The average cutting maintained during the work was 40 square feet per shift, or five feet per hour. In figuring the comparative costs of the two methods of cutting rock walls in work of this sort, the following estimate will be of interest.

DRILLING COST PER SHIFT

Runner	$3.00
Helper	2.00
Power	3.00
Superintendent, oil, blacksmithing, supplies, etc.	2.00
Total cost per 8-hour shift	$10.00

The cost of drilling and broaching is estimated as follows: Assuming that 60 feet can be drilled per 8-hour shift, six 10-foot holes can be put down, and allowing three inches for the diameter of the hole, and one inch for the rib between, 20 square feet will be drilled per eight hour shift. Furthermore, it will take at least one-half as long to broach as to drill, or one-half shift, so that the total cost of drilling and broaching 20 square feet would be:

Drilling cost	$10.00
Broaching cost	5.00
Total	$15.00

Cost per square foot, $0.75.

The cost for running the channeler for eight hours was about $16.00, including runner, helper, superintending, blacksmith, and power. Therefore, averaging 40 square feet per 8-hour shift, the cost per foot was $0.40, a saving of $0.35 per foot, or 46⅔ per cent over the method of drilling and broaching.

Results fully approved the judgment of the contractors in the work above described. The channeler demonstrated its right to be called an important addition to the contractors' equipment, and it has come to stay in New York City work.

In addition to the Sullivan channeling machines, ten Sullivan rock drills were used for drilling the blasting holes between the channeled walls.

The photograph reproduced herewith shows an interesting feature of this work, namely: The deck and supporting timbers necessary in order to carry on the work without interfering with the street traffic.

THE CRANBERRY MINE

METHODS AT A NORTH CAROLINA IRON ORE PROPERTY

By B. C. Hodgson [1]

The mine of the Cranberry Furnace Company is situated at Cranberry, North Carolina, in the northern part of Mitchell County, on one of the eastern slopes of the Smoky Mountain range. The company, or its parent corporation, the Cranberry Iron & Coal Co., owns some 4,000 acres in this vicinity. Ore from the mine is concentrated at Cranberry and shipped to the company's furnaces at Johnson City, Tennessee, 34 miles distant, over the East Tenn. & Western N. C. R. R.

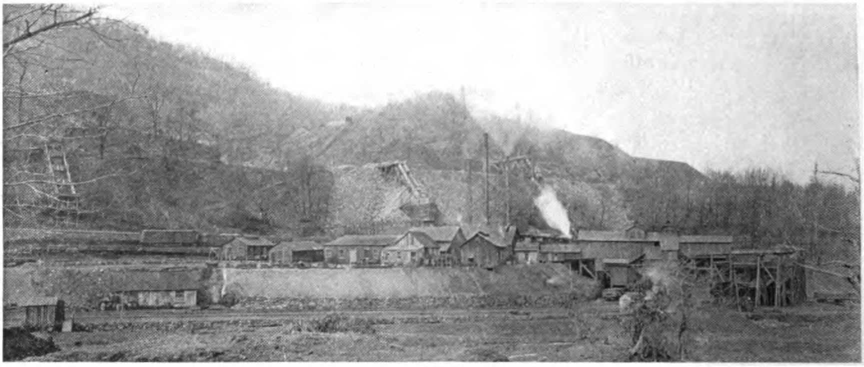
GEOLOGY

The ore deposit is in the form of a large lens, whose limits have not been fully determined. It consists of a high grade of magnetite, associated with pyeorene epidote, quartz, feldspar, calcite, garnet, and other minerals. Its low content of phosphorus renders it a very desirable ore for all uses. It varies in character, some parts of the deposit being fine grained, massive and dense, and others soft, coarse, and granular. This latter is known locally as "rattlesnake" ore, from the diamond-shaped marking of the granular accretions. The deposit is a vast body of ore and rock, with the ore scattered promiscuously through it, in varying purity, but usually in the form of bands or lenses. The thickness of these bands varies from a few inches to 70 feet or more. The highest outcrop on the ridge is about 400 feet above the water level of Cranberry Creek. The photograph on page 510 shows a general view of the mine openings at the three levels on the side of the ridge, together with the concentrating plant, power house, and ore chutes.

HISTORY

The Cranberry iron ore deposits are much the most important in North Carolina. The value of the ore was understood as early as 1820 or 1825, when it

[1] Knoxville, Tenn.



The Cranberry Furnace Company's surface plant.

was worked in a small way in catalan forges. The quality of the iron from these forges attracted much attention. In 1866 it was tested in the Naval ordnance yards at Washington with satisfactory results.

The owners of the forges merely stripped off the loose, friable surface ore, and for many years further development was retarded by the lack of funds. About 1875 the property came into the hands of the present owners, who have developed a body of ore that is on a par, in extent and quality, with the Lake Champlain and New Jersey deposits.

MINING METHODS: UPPER LEVEL

The mine is operated from three main and several sub-levels. From the upper level, at almost the top of the outcrop, 350 feet above the creek, three slopes are being sunk in and with the ore body at an angle of 38 degrees. These slopes have been advanced about 150 feet. This band of ore is 20 feet thick at the outcrop and has been shown by diamond drilling to attain a thickness of 70 feet, at a point 400 feet in from the surface, measured along the dip.

The ore is drawn up these slopes by separate hoisting engines, in end dump cars of 3,000 pounds capacity. The cars are then run to the gravity incline (See page 512) on which they descend to the second or open cut level. Here the ore is dumped through a chute 80 feet long into bins on the lowest or main tunnel level. The gravity incline is 145 feet in height and 275 feet long.

OPEN CUT LEVEL

Until three years ago this part of the mine was worked only as an open cut. So much rock was encountered, however, in the face of the workings, that this method was abandoned and tunneling and drifting substituted. (See page 511.) The distance across the open cut floor from the foot wall to the hanging wall is 400 feet.

TUNNEL LEVEL

The main tunnel has attained a distance from the surface of about 450 feet. There are several large workings on this level. Three slopes have been sunk from it at an angle of about 30 degrees, to a depth of about 400 feet in the ore body. From these slopes drifts to right and left are turned, and on the drifts large stopes have been opened. These stopes frequently attain a vertical height of 70 feet, all in ore. Crews of men are regularly employed to mount on ladders to the tops of these chambers and pick down the loose fragments from the roof and walls, after a

The open cut level.

A room or stope in the Cranberry mine.

Gravity incline and entrance to slopes on open cut level.

blast, in order to protect the miners below. Some idea of the height and area of these great chambers will be obtained from the photograph on page 511, taken on the tunnel level.

From the main tunnel level a drift is being extended to intercept slope No. 2 from the upper level. The vertical distance from the floor of this drift to the floor of the upper level is 225 feet. A second drift, on a level 60 feet below the first, is being sunk in the same ore body, and will eventually intercept the No. 2 slope at a distance from the surface of about 1,800 feet.

GROUND BREAKING

About 30 standard piston rock drills of 3⅛ and 3¼-inch cylinder diameter are employed for breaking ground. These drills are mounted on tripods or mining columns and are driven by compressed air at 90 pounds receiver pressure. The ample size of the pipe lines and their careful arrangement and maintenance render pressure losses very small. Air re-heaters, burning coal, insure dry air at the drills and further minimize transmission losses. Both the rock and the ore itself are very hard, rendering the drilling slow and throwing a heavy burden on the drills. In recent diamond drill prospecting, the average progress was ten feet per ten-hour shift, but for much of the work only two feet per shift could be drilled. This will give an idea of the severity of the drilling conditions.

DRILL MAINTENANCE

The cost of drill maintenance resulting from this difficult ground induced the mine officials to conduct very thorough tests on different kinds of drills. This investigation resulted in the adoption of the Sullivan 3¼-inch tappet valve drills, which gave the best results in drilling speed and in repair costs per foot. Since these drills were put in, nearly two years ago, there has been a noteworthy reduction in maintenance charges, and an increase in the amount of ground broken per drill. The average drilling speed in this mine is about six feet per hour, or 30 to 40 feet per ten-hour day, including setting up, tearing down, and moving the drills. The ore is removed in benches, from 15 to 70 feet high, and the average depth of holes drilled is eight feet.

Mr. J. M. Cameron, general superintendent of the company, has designed an automatic lubricator which is used on all the drills at this mine and has maintained their efficiency at a high level. The oil chamber is so arranged that the oil is under air pressure, the pressure above the surface of the oil being about 15 pounds in excess of that at the discharge opening. This results in injecting a small quantity of oil into the cylinder at every stroke, and thus keeps the drill properly and positively lubricated at all times.

HAULAGE

The main tunnel level is equipped with a system of tracks serving all parts of the

mine. The ore from the two upper levels as noted above, is dumped into bins, and thence into mine cars. These cars run by gravity, in trips of five, to an incline, up which they are hauled by a cable and dumped directly into the crushers. The empty cars are hauled back into the mine by mules. The track gauge is 36 inches and the car holds 3000 pounds of ore.

VENTILATION AND DRAINAGE

No artificial ventilation is required. The mine makes but little water in any of its workings, and is kept dry by a pump of 200 gallons capacity, running less than half time. These conditions render labor conditions much more agreeable than usual in a mine of this size and character.

CONCENTRATION

The concentrating plant is directly at the entrance of the mine, (see cut below). The ore is first crushed by two gyratory crushers, with the usual equipment of screens, washers, and conveyors. The ore is screened into five sizes: 3½-inch or "cobbed" ore, 1½-inch, 1⅛-inch, and ⅝-inch and "dust." The crushed ore is separated from the waste rock by passing it over electro-magnets, of which ten are in use. These magnets were designed by Mr. Frank Firmstone, a director of the Cranberry Furnace Co. They are of the revolving pattern, with a belt on which the ore is carried over them. These magnets have proven very efficient, and cost little to maintain. Some have been running for upwards of four years without any repairs.

The "⅝-inch" and "dust" sizes are carried to the separator by water and the ore is lifted from the water by the half submerged magnets. The ore is run either to bins or directly into railroad cars which carry it to the company's furnaces at Johnson City, Tenn.

POWER PLANT

The power plant consists of 500 horse-power boilers which operate the compressor and engines, a 2000 cubic feet cross compound two-stage air compressor, one 80 horse-power Corliss engine, which drives the crusher, magnets, etc., etc., in the concentrating plant, and a 50 horse-power engine which drives the dynamo for the electro-magnets and the lights in the plant and mine. There are well-equipped carpenter, machine and blacksmith shops. The company builds its own mine cars.

The village of Cranberry has a population of about 600, of whom one-half are miners. There is a church, a school, hotel and a large company commissary. Good water is available, and the climate and sanitary conditions are excellent.

Aid in preparing this article is acknowledged to Mr. J. M. Cameron, superintendent, and to Bulletin No. 1 of the North Carolina Geological Survey.

Concentrator, Cranberry Furnace Co.

INDEX TO MINE AND QUARRY.

FROM MAY, 1906, TO MAY, 1911, INCLUSIVE.

(BY SUBJECTS.)

INDEX BY MACHINES.

If interested in special classes of Machinery, the following cross-index will be found of assistance in looking up applications and performance. The numbers refer, not to pages, but to the figures shown before each title in the subject-index.